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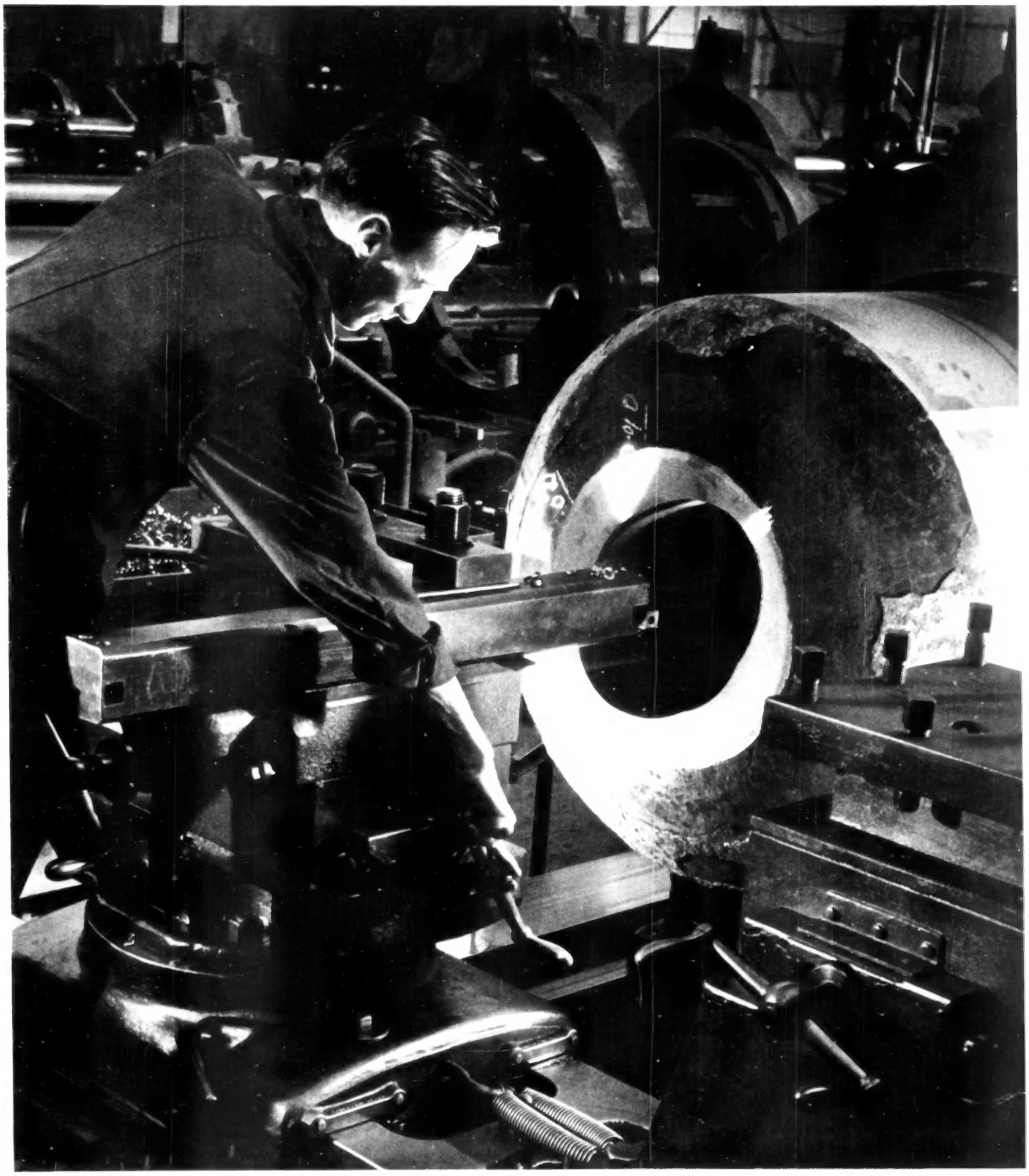

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DECEMBER 20, 1957 VOL. 184 PAGES 769-800

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Vol. 184 No. 4789 DECEMBER 20, 1957

Leading Article
The Pressure to Develop 769

Plain Words 770

Special Article
Treasure-Trove in the Sahara 770
No. D500 : Diesel-Hydraulic Locomotive 773

Companies in the News 772

Letters to the Editor
Locomotive Orders 773

Book Reviews
Thermal Stresses: With Applications to Airplanes, Missiles, Turbines and Nuclear Reactors 782
Air Conditioning 782

Trade Publications 783

On the Shelf 783

Atomic Review
Materials Miscellany 792

Notices of Meetings 798

In Parliament 799

★ ★ ★

Plant and Equipment
Automatic Profiling of Steel Plate 774
Fork Lift Truck with Forward Reach 775
High Temperature Heating 775

Metals and Materials
A Modern Synthetic Rubber 775
Engineering Standards for Pressure Die Castings 775
The Hylite Titanium Alloys 775

Management
Give Engineers Responsibility While They're Young 776
Weekly Survey 777

Marketing
Canada's Wants and Fancies: Brief Guide to the Market for Engineering Products in Canada 778

Research and Development
Physical Research Applied to Machine Design: High Power Fluid Transmissions 779
Metal Films and Fluid Flow 781
Extending the Use of Printed Circuits 782
Aboriginal Recording 783

Design
Physics in Reactor Design: A Pictorial Summary of Elementary Nuclear Concepts 784
Italian Nuclear Research 787
Advisers for Italy—and for Turkey 787
Plate Girder Design: Flange Stiffness and Web Plate Behaviour 788

Production
Transformer Factory 795
Methods for Cleaning Boilers 796
Retaining Accuracy in Copy Drawings 796

Construction
Re-building after the Jaguar Fire 796

The Human Element 800

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THE PRESSURE TO DEVELOP

THE future of the aircraft industry is actively under consideration by the Government. Its problems are of vital relevance in more ways than one to industry as a whole. They are a high-speed version of industry's continuing problem of adapting its organisation and the training of its staff to technological change. The way in which the aircraft industry is going to-day, others may go more slowly to-morrow. They would do well to learn from the aircraft industry's agonies.

A first point to emphasise is what might be called the false rate of development in the aircraft industry. Owing to circumstances beyond its control, mainly the need for military preparedness, the industry has always been pushed to develop new ideas in accordance with revolutionary specifications. Ideas have followed one another on to the drawing board with scant regard either for the accumulated experience of research workers and designers of aircraft which were the last word yesterday but are proclaimed obsolete to-day, or for economic production. To say this, is not to criticise the aircraft manufacturers nor to deprecate the very real advantages which such rapid development has had in developing new fighters and bombers, but there are other aircraft, of which the Viscount is one, which have had a somewhat less dramatic development with outstanding technical and commercial results. The aircraft industry's experience is in complete contrast with, say, marine and railway engineering, where the pace of progress has been slow, tied to tradition and often lacking in research resources or the need for a revolutionary attitude in design. Somewhere between the two extremes lies an optimum rate of technical progress, a rate which is likely to be the optimum for the aircraft industry in future as well as for older branches of engineering.

A second aspect of the aircraft industry's high-speed metamorphosis is the need which it underlines for greater organisation and supervision of specialists. This is one of a number of vital topics which Sir Ewart Smith illuminated in his Graham Clark lecture, reported on page 776. If scarce but highly experienced technical manpower is to be co-ordinated efficiently in a re-organised aircraft industry, or in any industry, the co-ordination has to take place on two levels. There is the co-ordination by a technical man who has the supervision of a department or a group of departments, and there is beyond it the overall supervision at top management and board level of departments and even different companies. This is a problem which will increasingly face the large engineering group, just as it now faces the nation's scientific effort as a whole. But apart from the wider aspects of the national scientific effort, the trend towards bigness is likely to continue in private as well as public enterprise. Such developments as the European Common Market and the Free Trade Area offer prospects of success for the big and efficient battalions. But the recent sub-contracting history of certain companies in the aircraft industry are examples of the difficulty in co-ordinating the development and production of complicated modern equipment and of the need to develop new techniques.

It is clear that at the lower levels of control, the technical man must be in charge. As industrial units grow bigger and handle an increasingly complex series of technical problems the task of co-ordination at the top becomes increasingly important. The day is fast approaching when the lion will have to lie down with the lamb. The top-level administrator and the top-level co-ordinating technical man must make their peace and learn to live together. It is going to be increasingly difficult for the non-technical administrator or board member to think constructively and relevantly on broad issues which stem from a multiplicity of technical matters. It is going to become equally difficult for the top-level technical man to see the wood for the trees unless he can sharpen his intellect frequently and systematically against the man who is trained to see the broad issues. The days when the non-technical administrator and the top-level engineer or scientist can quarrel about each other's suitability for control are numbered.

A third group of problems stems from this, so far as the trained engineer is concerned. He must learn a specialism beyond his conventional technical training in this world of specialists, otherwise he will never be promoted up the technical ladder, but he must early be taught to manage and to think in terms of broad issues if he shows promise beyond his technical expertise. This is a very difficult specification for the engineer of to-morrow. He must become increasingly a specialist and then increasingly a non-specialist. There are resources within the engineering profession which can help to some extent. The prospect for developing co-ordinating techniques could give a unique opportunity to consulting engineers as a whole, for clearly a part of the technique of control from the top is to mix efficiently the internal resources of the group with outside ones which have broad if less highly specialised experience. The engineering profession may be on the threshold of a rate of development as vast and exciting as the technical problems it handles.

Cover Picture. *Manhole covers in boiler drums are made oval for two main reasons; the first is that the joint is usually made on the inner face and the oval allows the cover to be inserted and withdrawn; and the second is that an oval approximates to the cross-section of a human body. After boring a circular hole the oval shape is machined by a cam-controlled movement of the cross slide, synchronised with the rotation of the drum.*

* * *

Plain Words

Fears that *homo sapiens* will slowly but inevitably lose the power of locomotion by his legs have been expressed ever since the advent of the motor-car. It was an American tourist who, tired of trudging round the sights of London with his zealous wife, in reply to her question as to what he thought God had given him legs for, said: "I guess one was for the gas and the other for the brake."

Ought we not to express ever-such-a-little fear on behalf of our hands? They are just as likely, it seems, to evolve into flapping, button-pushing instruments as our feet are likely to become built-in jacks and pedal operators. There was a time when the smooth manipulation of a "crash" gearbox on a car was a skill of which one could be proud. There was an art, too, in switching the belt of a lathe from one set of pulleys to another while the spindle was still running. As for hand ramming the sand in a foundry mould, that was an art which only the experienced moulder had had the time to acquire; no amount of holiday sand-castle making for the children could impart the subtle skill needed for this operation.

But ever since we left the oily, swarf-cut floor of the machine shop and the black sandy ground of the foundry, we have been participating, directly or indirectly, in the business of eliminating the need for skill in production processes, in doing the week's washing, in driving a car, in tuning a radio, in knowing how to drive across a road junction without hitting the other fellow. Just as an old soldier never stands up when he could sit down, and never sits down when he could lie down, so no job should be skilled if it could be semi-skilled, or semi-skilled if it could be unskilled. As one would expect, only in the arts is manual dexterity persistently and deliberately fostered. An organist, a violinist or a concert pianist packs more skill and high-speed finger movement into ten minutes of *allegro vivace* than any industrial worker.

There is at least one bright spot in the battle to save our hands: the mothers of the future may preserve the efficiency of our hands because so many of them achieve great skill in operating typewriters and calculating machines. If those machines vanish, replaced by writing and calculating machines which respond to the human voice, there will be only one way open to us—we shall have to design machines which combine pleasant past-times with physical exercise. But by that time it may not matter: we shall be all brain anyway.

TREASURE-TROVE IN THE SAHARA

The oil rush in South Algeria could not have come at a worse political moment. French enterprise in the oilfields has become the focal point of national resistance, and the desert the scene of the bloodiest struggle of the Algerian War. But the French themselves, who desperately resist the taxes requested to pay for their armies, are ever ready to invest large sums in schemes which must remain huge political gambles for a long time. Estimates of Algerian oil reserves are constantly being revised upwards: "established exploitable reserves" are now set at 200 million tons, "probable reserves" at 500 million tons and "possible reserves" at 1,000 million tons. Only a few months ago total reserves had been estimated at 1,000 million tons. There is little doubt now that there is an immense potential and it is quite plain that the French intend to make it their own. The recent arms deal by the United States and the United Kingdom with Tunisia was widely interpreted by the French as a manœuvre to get in by the back door and undermine French control. The explanation that it was this or Soviet arms made no impression whatever.

Oil is not the only mineral wealth of the Sahara: natural gas, coal, tin and other raw materials are known to exist in abundance. To the French this could mean independence from imported supplies and a source of low-cost power long before atomic energy can provide their needs. But in reality it is a development of European significance and a source of great strength to the Common Market or any free trade area that may be formed. Mr. Macmillan's recent visit to Paris, with Mr. Maudling (who concerns himself with free trade area problems), is an attempt to bring this home to the French. Inevitably it must become so, and the sooner it is realised and a full European programme put into action, the more likely is a peaceful solution to be found. A hundred years ago the French lost control of the Suez Canal but they still retain the industrial and commercial control of Egypt: similarly in the case of Algeria the 1½ million French population could preserve their influence and grow immensely in consequence.

The French Ministry of Industry and Commerce have already earmarked something like £250 million in a capital programme for oil exploration in the next five years or so, most of which is expected to be channelled to the Sahara. A spokesman for the Ministry predicted a possible 4 million tons of oil could be piped out of the area by 1959. And in time, as production picks up, a possible output of 50 million tons of oil annually is envisaged. That is roughly 50 times France's present yearly production of crude and almost double the amount of crude oil imported into the United Kingdom in 1956. In the words of M. Mollet: "The Sahara could be . . . the federative element uniting all the border countries in a common prosperity."

To the Moroccans and Algerians, the mineral wealth of the Sahara is an escape from poverty of all sorts. Industrialisation to them, and to all North Africans, is the only means of raising near-starvation existence levels. It is an optimistic promise of a new look to housing and transportation; a desperately desired uplift to the nearly 2 million faces of the Sahara. They feel industrialisation would not only result in direct wealth from minerals, but would indirectly provide the capital and the incentive to cultivate the agricultural market. For industrialisation could not be accomplished without development of water supplies. The rainfall averages less than 8 in. a year and plant life is scarce. The majority of the population earn a haphazard living as nomadic stock raisers or oases farmers. But farming is confined to the oases, either where there is a natural water supply or where it has been possible to sink a well to an underground water table and, at present, dates are the only farm export. Grain is produced in inadequate amounts and stock raising is seriously hampered by droughts. The Sahara is thus forced to rely on imports for the major part of its food needs.

THE SAHARA TO-DAY

While many private companies of all nations are jointly exploring the Sahara, the major part of the development is being conducted under the guidance of government committees and nationalised firms. France has recently set up a Common Organisation for the Sahara regions to supervise and co-ordinate surveys of resources, promote general development programmes, prepare for installations for extracting industries and the like. The work of the organisation should not be confused with that contemplated by the Common Market countries. A Committee for Studying Areas of Industrial Organisation in the French Union, established in mid-1950, originally fired interest in the Sahara's potential. Soon it was working closely with the Bureau for Organising African Industrial Areas, instituted by decree in 1952. The latter is mainly engaged with setting up an industrial zone on the Algerian-Moroccan border while co-ordinating the action of the government-operated North African prospecting organisations. Privately-owned companies—French, English, Dutch, American and others—are also teamed together, particularly in exploration for oil in the Eastern Sahara.

Exploration and research in the Sahara, hampered by the War and intense only since 1950, has been most systematic in the north, along the Algerian and Moroccan borders and it is here that the largest variety of minerals has been indicated. However, in the south, Mauritania's lucrative iron ore deposits are getting their fair share of close scrutiny, while in the Eastern Sahara good shows of oil appear to be the main prospect.

CIVIL ENGINEERING PROBLEMS

To get at the resources and to export them means first of all a transformation of the desert in terms of roads, railways, housing and water supply. There are only four main roads—north to south routes—in the Sahara to-day and only two main rail lines to the Mediterranean coast. Many more miles of roads and railroads would have to be constructed to make industrialisation of the Sahara a paying or even a practical proposition. This would very probably mean a full-scale recruitment of engineers and other technical men from France, England and the rest of the Continent as local labour is primarily unskilled. Even now, Dutch, British, Swiss, French and other nationals work side by side. Pipe lines would also have to be built to carry water to dry spots from reservoirs (also to be constructed) in the more fertile areas. An underground river flowing southward from the Atlas Mountains to El Goléa in central Algeria has an annual flow of 6,500 million cub. yd. of water.

COAL

Until the recent oil strikes in the Hassi Messaoud area, by far the most activity and prospecting was centred around Colomb-Béchar, primarily a coalmining area about 300 miles south-southwest of Oran which is on the Mediterranean coast of North Africa. A standard gauge railway, 318 miles long, links the city to the Mediterranean port of Nemours and a 468 mile narrow gauge railway runs from Oran to Colomb-Béchar. Production from the mines here (which is good coking coal discovered in 1907 and exploited since 1917) currently averages more than 300,000 tons a year. Only

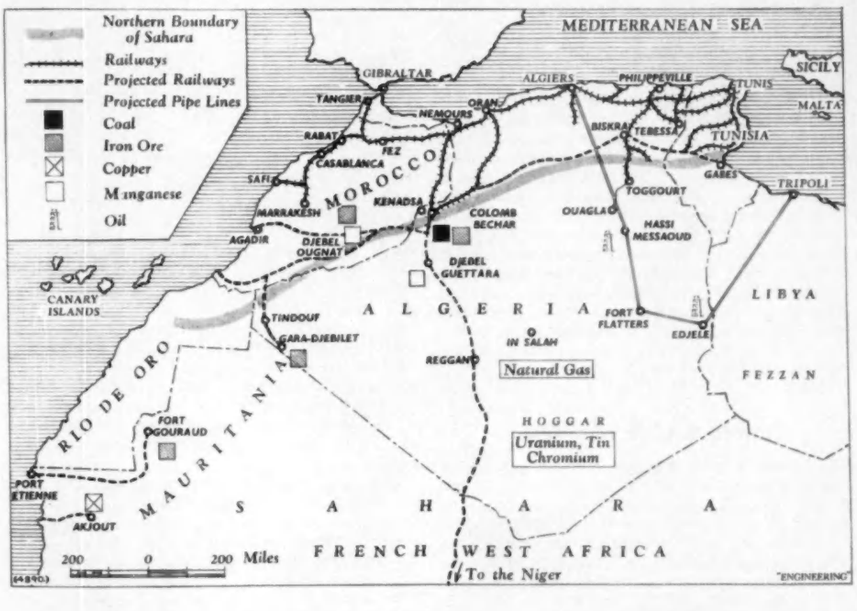
one of the three deposits of this basin is being worked, by the South Oran Coal Mines Company, who are Government operated. Exploitation of another of the three, by the same firm, is now getting under way. It would be possible for this coal to be transported from the mine by the Mediterranean-Niger railway which runs along the north-west edge of the basin. In contrast to this, prospecting of the third deposit is being held up due to lack of direct roads. This deposit, while only about 40 miles from Colomb-Béchar as the crow flies, is 150 miles distant by the available roads. It is possible that these coal deposits, together with ferrous and non-ferrous minerals in the region, would provide a good background for an industrial area. The region has the added advantage of being protected by the Atlas Mountains and thus in a favourable strategic position. Coal has also been spotted around Tindouf, 470 miles south-southwest of Colomb-Béchar and at In Salah—more recently of natural gas importance—almost due south of Colomb-Béchar. But again lack of transportation facilities is the difficulty and the reason why these coal mines have always operated at a loss. Looking ahead, however, their operation could become profitable if the coal could be used on the spot in the production of electric power, gas and chemicals or pig iron.

LARGE IRON ORE RESERVES

The Colomb-Béchar region is known to contain substantial deposits of iron ore. A French mining team sent to this area a few years ago reported it was possible that more than 500,000 tons of ore, with more than 60 per cent. iron, could be worked from open pits. The report added that an equal amount of ore was probably to be found at deeper levels; these, however, would be harder and more expensive to mine. A further estimated 30 million tons of iron, with grades ranging from 40 to 60 per cent., were discovered in the Djebel Ougnat Mountains west of Colomb-Béchar. Another iron deposit, containing between 400 million and 1,000 million tons of ore of at least 50 per cent. grade, has been located near Tindouf.

Tindouf is a desolate spot, far removed (470 miles) from Colomb-Béchar and its rail outlet to the coast. This apparently does not dampen the enthusiasm of mineral-hungry countries, particularly since these deposits—which could be worked primarily above ground—are considered excellently suited to the needs of the European metallurgical industry and in quantities large enough to supply iron to all European industry for centuries. The estimated reserves here are more than 100 million tons. It is thought that 5 million tons of ore a year could be mined at Tindouf, but it would require more than £35 million to exploit. Overall, about £100 million would have to be found for installations and services, including a railway across South Morocco to the coast and a port on the coast. Coal deposits are also believed to lie in the region. However, the most valuable iron discoveries of recent years have been in Mauritania. The full extent of the finds are still being determined by the Mauritanian Iron Mines Company (Miferma), established early in 1952 expressly to explore the iron prospects here.

The company, with initial capital of about £480,000, is controlled (51 per cent.) by French interests; a Canadian company owns 34 per cent. and the British Iron and Steel Corporation 15 per cent. In this area, where reserves probably amount to between 50 and 100 million tons of 62 to 68 per cent. grade ore, mining is being slowed down by problems of transport (again no railways and bad roads) and financing. The capital needs for development approach £40 million, this to include building a 400 mile rail connection to Port Etienne on the Atlantic coast. The company hopes to get some of the needed investment from steel producers, and the High Authority for Coal and Steel is known to be interested. To make an adequate return on the investment about 4 million tons would have to be extracted annually over a 25-year period. As far as reserves go this could be done, according to Miferma, provided financing and transport issues were resolved. The company feels it would not be economical to build steel plants in the area, but would prefer to export most of the ore.



OIL IN PLENTY

Despite proven and indicated reserves of coal and iron—plus smaller and as yet undetermined lead, tin, copper, manganese and possibly uranium deposits—the greatest single hope of the Sahara is oil. The North Africans, French, Dutch, British and others who have spent more than £20 million in the past ten years within the French Union searching for oil, are banking on it as the hinge to prosperity. It is too early to say whether refineries would be built on the spot. The firms are more concerned with keeping transport costs down (most finds are far inland) in order to keep prices competitive with those of Middle East oil.

A number of companies has been formed by various interests since 1946. They are currently drilling and exploring on government concessions and feel confident their investment will prove worth while. Only within the past four or five years has the Government granted oil concessions: they now cover more than 270,000 square miles of the Sahara. Proven oil strikes seem to be fairly well concentrated in the south-east of the area. The most important finds are at Edjele, near the Libyan border, and more recently at Hassi Messaoud, west of Tunisia. Six wells have also been drilled at Tiguentourine, 43 miles north-west of Edjele, and two more are drilling.

COMPANIES IN THE SWIM

The Hassi Messaoud oil strike is being worked by the National Company for Oil Exploration and Exploitation in Algeria, first-born of the companies now looking for oil in the Sahara. The firm is jointly owned by the Algerian Government and France's official organisation, the Petroleum Exploration Bureau. The total oil deposit at Hassi Messaoud is estimated at 1,000 million tons. The oil sands are thought to be at least 522 ft. thick. This compares with an average productive pay zone in the Middle East of 140 ft. The output potential of the four wells now working is estimated at 5 million tons a year by 1960. Based on this, it is planned to lay a provisional pipeline from the strike to Touggourt or Biskra, from where the oil could be carried by rail to the coast. If, after further exploration reserves warrant it, construction of a 350-mile pipeline to Philippeville on the Algerian coast of the Mediterranean is expected to begin in 1958, with completion by 1960. In the interval it is planned to start limited production at the rate of 150 tons a day. Next year another pipeline is to be built to carry as much as one or two million tons of crude per year.

Meanwhile at Edjele, where Saharan oil was first discovered in noticeable amounts (in 1955), later tests continue to raise optimism that the desert could be another Middle East. Exploration here is being conducted by the Saharan Oil Exploration and Exploitation company, 55 per cent. owned by Régie Autonome des Pétroles, the autonomous French state entity; 35 per cent. by the Royal Dutch Shell group—representing the only United Kingdom participation in the area—and the remainder by the French official organisation and the National Company for Oil Exploration and Exploitation in Algeria. (Through a 65 per cent. Royal Dutch Shell interest in the Algerian Oil Company, the British are also looking for oil around El Goléa in central Algeria, but so far nothing definite has been unearthed.) At Edjele 13 wells have thus far been drilled and two are drilling. Most are shut-in ready to produce and one well is now producing gas oil which is being used for the local oilfield without further refining. The first well at Edjele was reported to be giving 19 barrels an hour on production tests, or an estimated annual capacity of 20,000 tons. With all wells producing at this rate, it would mean an annual production of 240,000 tons. But production here and at Tiguentourine must await construction of a planned 16-in. 500-mile line to link both fields to a point on the Tunisian coast. The cost of the line, together with the aforementioned Hassi Messaoud line, would run to £55 million, while a further £40 million would have to be spent on bringing the three fields into commercial production. More recently a consortium of five French and American companies has been formed to carry out prospecting in the Sahara: Lazard Fréres 18 per cent.; Newmont Mining Corporation, New York 18 per cent., Omnium de Valeurs Agricoles Industrielles et Minieres Paris (OVIAN) 10 per cent.; Société Anonyme Française de Recherches et d'Eploitation de Pétrole (SAFREP) 27 per cent.; and Sinclair Petroleum Company (a subsidiary of Sinclair Oil Corporation) New York, 27 per cent. SAFREP has already asked for search permits on behalf of all five companies taking part, particularly in the zones recently handed over by the Compagnie Française de Pétrole de Algérie and the Société

Nationale des Recherches de Pétrole de l'Algérie. Also City Service Oil Company, a United States concern, are setting up a French subsidiary, the Prepa-Francarep-City Service group, in which they will hold 50 per cent. of the equity. The formation of a new French company, Petrosarep (a subsidiary of Petrofrance) was announced in August. In September British Petroleum lodged applications for concessions in Eastern Sahara. British Petroleum were the first to accept the French Government's condition that there must be a 50-50 association with French interest. The big American companies with international ramifications on the other hand have so far insisted on being given a major share in any Sahara research association.

BASIC INVESTMENT NEEDS FOR THE SAHARA

If all necessary capital were immediately available, production could not get under way for some years to come. Hassi Messaoud, Edjele and Tiguentourine lie in terrain especially unfavourable to exploitation—even by Saharan standards. The fields are close to the Great Eastern Erg, a succession of sand waves that sometimes reach a height of 1,000 ft. and are nearly 300 miles long. To complicate matters even more, the climate is too hot to work full force from June till September, though drilling crews go on 24 hours a day in any weather. And higher temperatures mean more than the 22,000 gallons of water needed daily to drill during the cooler autumn and winter. Every drop of water has to be carted for miles in tanks and all equipment has to be carried across Algiers along 600 miles of bad or non-existent roads. All food has to be flown in.

Apart from oil, a large natural-gas field that could yield 1,460 million cub. m. a year, has been found at In Salah, south of El Goléa in central Algeria. Reserves here have been estimated at 10,000 million cub. m. Such production—too much for Algerian domestic needs—could justify expenditure of £30 million on a 600-mile pipeline to the coast but only if there were an industry to use the gas. A plan is currently under study to industrialise some of the Algerian towns. Estimates of both the scale of investment required in the Sahara and of its oil potentialities vary; the latest estimate by Monsieur Max Lejeune, French Minister for the Sahara, is that by 1960 a total of Frs. 250 milliards (approximately £250 million) will be required. To help provide for the capital needs of Saharan development, the French State hopes to raise funds against its holdings in French oil companies by issuing " negotiable certificates."

But first, last and always, industrialisation spells money. Most of the investment in the Sahara to date has been at the expense of the French State. The Foreign Operations Administration of the United States Government announced in 1954 it had granted a small loan to the French Government. British, Dutch, French and other private firms have indirectly invested in the Sahara through their search for oil. But more is needed and the sum will be considerably greater when the stage of actual development has been reached. It is believed that the French, who are responsible for most of the Sahara, would turn to European capital before American. The French are not anxious to relinquish their control but it will be necessary for them to make inviting conditions for foreign capital, both private and public, if they are to get their full needs. In the words of M. Louis Armand, chairman of the Bureau for Organising African Industrial Areas and president of the French National Railroads: " . . . we must modify the concepts of French law so as to adapt juridical procedure to technical requirements and to the inherent necessities in the development of a desert."

Thus far, the key to the treasure chest of the Sahara has only been blanked out. Much more is required in the way of international co-operation and financing before the key can be cut and later turned to unlock the wealth of the Sahara.

Companies in the News

Toys at Peak

The toy manufacturing industry anticipates a record year. Home sales are expected to exceed £27 million (at manufacturers' prices) and exports £7 million. The Lines group, which is believed to be the largest maker of toys in the world, have subsidiaries in several countries, including Canada, the United States, South Africa and New Zealand. They have recently acquired Simpson Fawcett and Company, manufacturers of " Swan " baby carriages and that company's associates, Fry's (West of England) also a small chain of toy and pram shops, John Ward, was acquired recently. Moldex of Melbourne, Australia, were purchased in March. Mr. Walter Lines, chairman of Lines Brothers, told shareholders recently that he considered that this purchase, which includes freehold land and a modern factory with a large moulding plant, was effected " at a low cost."

Despite this considerable expansion, or perhaps because of it (capital commitments at home outstanding at June 30 amounted to £192,292), profits fell. Net profits after tax totalled £354,654 compared with £478,821 the previous year. Mr. Lines would not hazard a guess at the current year's profitability, since demand during the coming months must depend largely on pre-Christmas stock clearances by retailers. Mr. Guy M. Chantrey, chairman of one of Lines' major remaining competitors, Tan Sad Limited, perambulator and wheeled toy manufacturers, would not be drawn either on the future. Although trading profits for the last financial year were slightly higher than the preceding year net profits after tax (£19,984) were fractionally lower. Mr. Chantrey mentioned that mounting costs had forced the company to raise prices. He expressed concern that this trend should continue and lead to a fall in demand. This is a highly competitive market, particularly overseas where Germany and Japan benefit from lower wage rates, and the prosperity of the industry must depend on low manufacturing costs. Volume is probably the only effective answer to Continental competition and this leaves little room for the small firm.

* * *

Growth through New Ideas

The prospect that 80 per cent. of growth in manufacturing industry during the next six years will be in terms of products not yet made (a United States estimate quoted recently by Dr. Alexander King, E.P.A.) should not perturb the board, or shareholders, of Carrier Engineering. In his annual review their new chairman, Mr. R. S. Andrews, reported an improvement in trading profit of 13 per cent. and a continuation of the company's rapid growth. Mr. Andrews has taken over from the late Mr. Stanley Groom, founder, who had been chairman and managing director of the company until his death last September.

Looking ahead Mr. Andrews said that the company continued to pay very close attention to research and development: " new ideas, processes and equipm nt are constantly under consideration with a view to expanding our fields of activity." Like most others in their field Carrier will doubtless feel the impact of the fall off in capital investment which has been hastened by the Government's imposition of high interest rates and credit restrictions. These " may well result," he said, " in a temporary reduction in the demand for the type of capital goods we supply."

Nonetheless the company have proved themselves in the most competitive markets and there is every reason to expect a further growth in the demand for air conditioning plant in which Carrier specialise. Judged by American experience, demand for this type of plant is capable of a further considerable growth in this country and on the Continent. The development of a new system of air conditioning for multi-room buildings which the chairman mentioned in his speech, should once again place the company ahead and take full advantage of the trend towards large buildings, including hotels, now being erected everywhere in Europe. Carrier are among the best examples of a British company thoroughly in step with technical change and in tune with their markets.

* * *

Group Growth in Electronics

The proposed acquisition by the Pena Copper Mines Limited of Peto Scott Electrical Instruments and the latter's purchase of the Conrad Electrical Company is yet further evidence—if any was required—that the future in the electrical industry belongs to the large group disposing of considerable financial resources and with a well diversified output. The difficulties of cable makers this year show the importance of diversification within the electrical engineering field. The damaging impact of fluctuations in copper prices lends support to the view that producers of electrolytic copper could do worse than to associate themselves with users of their products. Major-General E. L. Bols, chairman of Peto Scott, makes no secret of the fact that the shortage of capital and competition " with larger organisations, both in the domestic television market and in the field of electronic development " has forced them in to becoming part of a large group.

An interesting point made by General Bols is that in their field competition is forcing companies to provide extended credit terms, for 9 and 12 months. " Thus," he said, " the burden of financing is shifted by the credit squeeze to the manufacturing industry." This will tend to promote the growth of the large unit in this industry and the existence of the medium-sized firm will become increasingly difficult. The process of rationalisation is going ahead quite fast and is likely to gather momentum during the next year or so, especially if the present very high demand for television and radio receivers and equipment should drop suddenly.

The advantages of the large unit, with well diversified interests, are revealed by the Plessey Company, whose trading profits—£1·55 million —were slightly higher than the previous year (ended June 30). The advantages of scale in the production of radio and television components and also in a growing number of cases of electronic equipment, is such that such firms as highly developed as Plessey and Mullard would greatly benefit from freer trade conditions.

* * *

D.B. of Montreal

Few large companies in Canada can boast of a start made 75 years ago, or of a growth that has matched so well that of Canada's major industries. Dominion Bridge was founded in 1882 by an American engineer. The first of many bridges was a cantilever bridge built at Saint John, N.B.; in 1886 they completed the Canadian Pacific Railway bridge at Lachine, where their works was located. Phelps Johnson and G. H. Duggan, then the heads of the company, won international fame when D.B. built the Quebec bridge from 1910 to 1917.

Bridges have now become a comparatively small proportion of the company's total output although in 1900 it amounted to 90 per cent.

Structural steel framework, gate equipment for hydro-electric power schemes, cranes and other handling equipment, large vessels and equipment for the paper, chemicals, oil and mining industries, boilers and steel all form part of the company's production. Fourteen factories with 9,000 employees stretch across the whole country and they have places for a 40 per cent. expansion by 1960. D.B. claim to have pioneered " many aspects of steel fabrication " including the development of electric arc welding. They have built many all-welded buildings and bridges. They were the first to fabricate and erect in 1950 an aluminium highway bridge at Arvida, Quebec. D.B. are now engaged in the raising of the Jacques Cartier bridge at Montreal. This is undertaken for the St. Lawrence Seaway and Power Project and is believed to be the largest operation of its kind in the world.

The progress of this company is traced in a 75th birthday brochure. It is in fact the progress of Canada and it is to be hoped that their expansion target of 40 per cent. in 3 years will be matched by the Canadian economy as a whole. It will then be easier for British firms to establish themselves in this growing market, whose needs are outlined elsewhere in this issue.

★ ★ ★

Aircraft at the Crossroads

The Minister of Supply showed in the Commons last week that the Government is at least fully aware of the difficulties of the aircraft industry; an inter-departmental enquiry has been started into the problems of the industry, including the future of Government policy on aeronautical research. The reduction in the demand for military aircraft since the height of the rearmament programme had been substantial, and, though optimistic, he felt it unlikely that any increase in civil production would wholly offset the decline in military production. The widely canvassed need for consolidation of the aircraft industry into stronger units was also mentioned; the Government will encourage this in the placing of contracts.

Mr. J. A. R. Kay, general manager of A. V. Roe and Company, Limited, subsequently expressed the personal view that there was not room for more than three major aircraft companies and perhaps two engine manufacturers. This is capable of fairly elastic interpretation, in that he felt that the Hawker Siddeley Group should be regarded as one entity. The Group's view of the prospects is perhaps shown by their rapid expansion into other fields; aviation now accounts for only 30 per cent. of the Group's activities compared with 85 per cent. only two years ago. This is an interesting contrast to the completely opposite trend which was shown for several years by Vickers.

While it remains to be seen how far the process should be carried, the need for it seems to be generally accepted. There are, of course, snags; the difficulty of establishing effective liaison between design teams, working on the same project, which are scattered geographically should not be underestimated.

This is however a problem of organisation. The Society of British Aircraft Constructors fear that further cuts in the near future, together with those which have already been made, may reduce expenditure on research and development by as much as 50 per cent. This would be a very serious matter. The aircraft industry is at present the country's second largest exporting industry in the engineering field. With adequate support, exports could be expanded still further. Without, in view of the well-supported competition, they will almost certainly shrink. The traditional Government policy appears to be not to kill off a thriving export industry, but to let it die gradually—as seems to be happening in the case of cotton. This must not happen to the aircraft industry.

Letters to the Editor

LOCOMOTIVE ORDERS

SIR, In your issue of December 6, 1957 (page 710) under the title " Green Light for North British " there are two errors which I should be grateful if you would correct.

In the first place you said that the recent order for 52 main-line Diesel-hydraulic locomotives brings our order book under the Railway Modernisation Plan to 63 locomotives. This number refers to Diesel-hydraulic main-line locomotives only. The total number of locomotives on order from this Company under the Railway Modernisation programme is 147. The balance is made up of Diesel-electric main-line locomotives and Diesel-hydraulic shunting locomotives.

In the second paragraph of the same note you state that our order book is now in excess of £5 million. In the statement to which you make reference we made it quite clear that this figure of £5 million referred only to Diesel-hydraulic locomotives; our total order book is of course very much greater than £5 million.

Yours faithfully,
T. A. CROWE,
Chairman and Chief Managing Director.
North British Locomotive Co. Ltd.,
Glasgow, N.1.
December 11, 1957.

No. D600

As was reported in our Company note " Green Light for North British," referred to in the above letter, Britain's first main-line Diesel locomotive to employ hydraulic transmission was completed last month at the Queens Park Works (Glasgow) of the North British Locomotive Company. Running-in trials on local lines in the Glasgow area are preceding the transfer to the Western Region, where it will go into regular service in due course. Locomotive No. D600—it has yet to receive a name but is shown in the accompanying photograph—is of 2,000 h.p. and weighs 116 tons. It is the first unit in this high-power range to be completed out of the initial programme of 174 main-line Diesels ordered under the Railway Modernisation Plan.

Britain's first main-line Diesel-hydraulic locomotive.

The Diesel-hydraulic transmission principle has been used with success in B.R. shunting locomotives, but this is the first application on British tracks to a type of locomotive designed for main-line duty, and its performance under British conditions will be watched with particular interest in view of its successful application abroad. No. D600 embodies the N.B.L./Voith design of hydraulic transmission and N.B.L./M.A.N. engines which are being manufactured by the company under licence. Of the 63 Diesel-hydraulic locomotives on order, five are of 2,000 h.p. and 58 of 1,000 h.p. All will be employed in the Western Region.

WITH the first issue of ENGINEERING for 1958, several improvements in design will be introduced.

The overall page size will be reduced from 14¼ in. by 10½ in. to 13¾ in. by 10½ in., to make the journal easier to handle. The area and amount of editorial matter will not be diminished. A livelier design of cover will conform with the recommendation of the British Standards Institution, Aslib and other organisations whose members represent the users of technical journals.

Full details of the changes were given on page 709 of our issue of December 6.

Obituary

MR. F. G. CREED

Beginnings of Teleprinting

It is with regret that we record the death of Mr. Frederick George Creed which occurred at his home in Croydon, Surrey, on December 11. Mr. Creed, who was the inventor of the high-speed telegraph perforator and printer, or teleprinter as it is usually termed, was born in Nova Scotia in 1871. He entered the submarine cable service in 1885 and for the subsequent 10 years served as a land and cable telegraphist in North and South America. He came to this country in 1897 and, with the aid of an old typewriter bought for 15*s.* at an auction sale in Glasgow, developed and perfected his automatic telegraph keyboard perforator. He worked hard for a number of years before meeting success but at last, in 1912, he had the satisfaction of seeing his first teleprinter installed on the premises of a national newspaper in London.

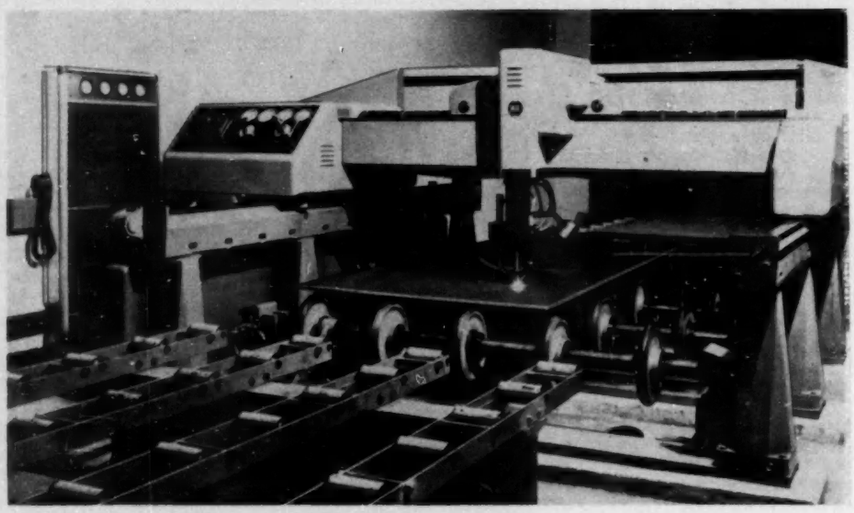
For many years Mr. Creed was chairman and managing director of Creed and Company, Limited, teleprinter manufacturers and telegraph engineers, Croydon, but he retired some years ago and turned his attention to the production of " unsinkable boats " and other craft. During the late war he was consultant to the Admiralty on small-ship design and in January of this year received the Freedom of the City of London.

Plant and Equipment

AUTOMATIC FLAME PROFILING OF STEEL PLATE

The shaping of steel plate by the oxy-acetylene cutting process is now quite common in shipyards and engineering works and in the majority of cases the machine employed has either replaced a mechanical shearing or planing process or takes the form of a portable machine. It follows, therefore, that until recently, oxygen-cutting machines, as they are usually called, have had little impact on procedures and methods which have been employed for generations in shipbuilding.

The first successful break-away from traditional methods occurred some years ago when the optical marking of plate was introduced in some Continental shipyards. In this process a photographic slide of a scale drawing of a profile is put on to a machine and this allows the automatic tracking of the slide to be carried out at the machine, thus eliminating the need for templates or for marking out the plate.



Front view of experimental computer-controlled flame profiling machine for steel plate up to 2 in. in thickness. The machine is the result of an application of machine-tool methods by Ferranti Ltd. to new developments in oxy-acetylene cutting by British Oxygen Gases Ltd.

Another, and quite recent, development involving what is described as a revolutionary computer-controlled flame-cutting machine has been brought to our notice and a new experimental machine was recently demonstrated at the British Oxygen Company's works in Angel-road, Edmonton, London, N.18. The machine, which is shown above, is the result of an application of machine-tool methods by Ferranti Limited, to new developments by British Oxygen Gases Limited in the field of oxygen cutting.

Computer-controlled cutting eliminates the need for many of the conventional stages between the drawing board and the cutting machine. The latter " receives its instructions " from a magnetic tape, and thereafter operation is entirely automatic as to shape, the correction of error and the monitoring of the services supplying the cutting machine. In practice, the part to be profiled is designed and drawn in the conventional manner except that, in place of dimensions specified as lengths between points, all dimensions are given as positions relative to the axes about which the machine works.

A planning sheet is then prepared from the drawing, and this gives the input information for the computer in the correct sequence, and such details as the cutting speed required, the kerf width (i.e., the width of the cut to be made) and the pre-heating time are given. Included also from the drawing are data regarding points of change and types of curve, in the order in which the profiling operations are to take place. The preparation of the planning sheet requires care and attention to detail on the part of the operator, rather than high skill, and when the sheet is complete, every movement necessary to produce the component has been specified.

The information on the planning sheet is then coded into the form of punched paper tape for use as input to the computer. A teleprinter for standard 5-hole paper tape is used for this purpose and copy-typing only is involved. A conventional typed sheet in ordinary characters is produced simultaneously for checking against the original planning sheet. The information on the paper tape is " read " by the computer which produces from it records in pulse form on magnetic tape for use in the control console of the cutting machine.

Transverse carriage and cutter head of computer-controlled flame profiling machine, showing, from left to right, in the lower half of the illustration, nozzle-height sensing probe, cutting nozzle, ignition electrode and flame-monitoring unit.

It is stated not to be necessary for manufacturers doing automatic flame cutting to own a computer. A centralised computer service is available and users can purchase " time " on this as required. In operation, coded paper tapes will be sent to the computer centre by shipyards, who will receive back, on a 24-hour service, reels of magnetic tape carrying all the instructions for use in the control console of the machine.

A control console is, of course, necessary for each profiling machine and, in brief, the operating procedure after the insertion of the magnetic tape is to locate the centre of the cutting nozzle at the datum position. This position, normally, will be the origin of the system of axes used in planning, with the work piece against stops fixed in relation to the datum. Thereafter, the machine proceeds under the control of the magnetic tape alone and no human intervention is necessary. Amplifying equipment converts the pulses in the magnetic tape into command signals which are fed to servo-motors on the X-Y axes of the machine.

In addition to the positional monitoring along these axes, other control elements, governed by an " auxiliary-functions " console, cover requirements peculiar to the flame-cutting process. These, which are seen in operation below, are (*a*) nozzle-height control, (*b*) automatic ignition and (*c*) flame monitoring.

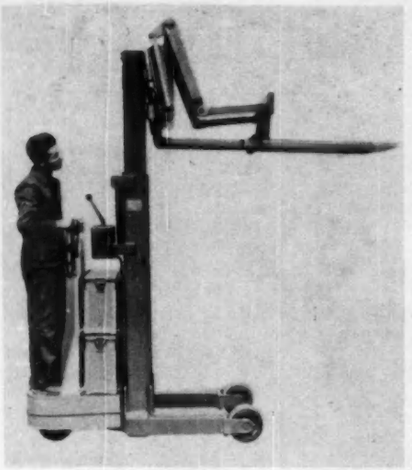
Continuous nozzle-height " sensing " is required in order to preserve the correct distance between the cutting nozzle and the plate. The automatic ignition system lights the gases on receipt of the command impulse from the magnetic tape. The flame monitoring unit confirms the presence of a pre-heat flame and the continuity of the cutting process. In the event of loss of cut or flame failure the machine is automatically stopped. A re-start sequence can be then initiated immediately.

Lastly, there is an automatic continuous monitoring of the performance of the control unit so that if for any cause, such as supply or component failure, some portion of the equipment ceases to function, the machine is stopped before any damage is done to the work.

The machine, developed for carrying out experimental work on automatic flame profiling, and shown above, is restricted to square cuts on plates up to 6 ft. by 7 ft. in size with a maximum thickness of 2 in. It is a small portal-type machine with a single nozzle and an elementary work table area comprising three distinct sections for the loading, cutting and discharge of the work piece.

The differences between the experimental and the production versions of the machine, now being developed, are mainly in layout and size, the production machine being of the " port-and-starboard " type with a capacity for cutting plates up to 12 ft. by 40 ft. on each side. Its method of operation is that power-driven rollers move the plate from a marshalling area up to stops in the cutting area. After the cutting operation, the plate goes forward to a 50 ft. discharge area. Naturally, all the essential features of the smaller experimental machine are incorporated in the production model.

It is anticipated that the development of the automatic flame profiling machine will have particular significance in all those branches of heavy engineering concerned with the fabrication of steel plate, a field which includes not only shipbuilding, but marine and structural engineering; locomotive, carriage and wagon building; the production of boilers, tanks and various forms of pressure vessels; the building of earth-moving equipment and heavy agricultural machinery and the manufacture of plant for use in atomic-energy applications.



The forks of this truck have a maximum forward reach of 24 in. and retract to within the wheelbase for travelling.

FORK LIFT TRUCK WITH FORWARD REACH

Shown in the accompanying illustration is a 1-ton fork lift truck in which the forks can reach forward 24 in. to pick up a load, and then withdraw to within the wheelbase for travelling. With this arrangement, pallets and containers can be lifted and set down in front of the chassis.

The truck, which itself weighs 3,500 lb., has a lifting capacity of 2,200 lb. at 25 in. centres, and a maximum lift of 18 ft., being provided with a three-in-one telescopic mast. As can be seen, the truck is very compact, and it is possible to handle pallets 39 in. by 30 in. in a gangway only 5 ft. 10 in. wide. The chassis has four-point suspension, with the two rear turntables interlocked to give a full 180 deg. turn. The speed is infinitely variable, the control being mounted on the steering column, and so arranged that lowest speed must always be engaged first. The truck is fitted with a " dead-man " foot-brake.

The truck, which is made by Steinbock G.m.b.H., is marketed in the British Commonwealth by G. Hunter (London) Limited, 80, Fenchurch-street, London, E.C.3.

HIGH TEMPERATURE HEATING

There are many applications where high temperature heating is required, in which it is not possible to use a direct flame, and uneconomic to use a steam supply. A heat transfer fluid which will operate at high temperatures with low vapour pressure is Dowtherm, and a system employing this has been developed by Hch. Bertrams of Basle, Switzerland, and is now being constructed in this country by Rose, Downs and Thompson Limited, Old Foundry, Hull.

High efficiency is obtained by using a boiler in which the heaters are built in and well insulated, but have practically no refractory setting. Gas or oil-fired boilers using Dowtherm in either liquid or vapour phase are being constructed with operating efficiencies of about 80 per cent. Dowtherm is a constant boiling mixture of 73·5 per cent. diphenyl oxide and 26·5 per cent. diphenyl. At a temperature of 100 deg. F. the boiler pressure is about 18 lb. per sq. in. rising to 80 lb. per sq. in. at 700 deg. F. The fluid has a characteristic odour that can easily be detected and has no known health hazards. The closed circulation of the fluid can be adjusted by means of mixing valves and a special four-way valve to give the required heating of either one or many units from a single boiler installation. It is claimed that temperatures can be regulated to plus or minus 2 deg. F.

Metals and Materials

A MODERN SYNTHETIC RUBBER

For over 20 years the Esso Research and Engineering Company, Linden, New Jersey, U.S.A., have participated actively in research and development work on synthetic rubber owing to the fact that many applications of rubber are closely associated with the consumption of petroleum products and also because petroleum is a source of raw material for the large-scale manufacture of synthetic rubber.

In the course of a lecture delivered in London recently and entitled " Development of Butyl, the Modern Synthetic Rubber," Dr. W. J. Sparks, who has been on the staff of the Esso Research and Engineering Company since 1936 and is now scientific adviser to the firm, stated that high molecular weight polyisobutylenes had first been made in the Esso laboratories in 1934. The chemical structures of natural rubber and the new material were similar in that they were both hydrocarbons with methyl side groups and they were both available in a wide range of comparable molecular weights. The polyisobutylenes possessed interesting resilience properties and high-molecular weight compounds of this type resembled natural rubber in other characteristics, such as solubility properties and X-ray structure under stretching. Moreover, the new material had all the essential physical features of natural rubber. For example, it was capable of rapid elongation and retraction, and the stress-strain properties resembled those of vulcanised natural rubber.

As polyisobutylene did not vulcanise chemically with sulphur, some degree of unsaturation had been required and work with co-polymers had shown that vulcanisation was possible with only 1 per cent. of unsaturation. The vulcanisable rubber of low unsaturation made by the co-polymerisation of a large proportion of olefin with a small proportion of diolefin had been designated butyl rubber.

Fillers were essential in the commercial utilisation of rubber. The application of reinforcing carbon black to butyl rubber indicated a chemical bonding between the butyl rubber and the carbon black and this material greatly increased the abrasion resistance of the rubber.

The successful commercial development of butyl rubber for the inner tubes of motor-vehicle tyres had occupied much time and effort, as many manufacturing problems had had to be overcome. The tyre problem had proved to be more challenging, but already butyl tyres had been shown to run more coolly and to have a longer life than tyres made from other rubbers.

For tyres for military vehicles which must be stored for long periods at a time, the property of oxidation and resistance to ozone assumed great importance. As butyl tyres did not develop side-wall cracking as a result of attack by ozone, the United States Army had sponsored the development of military butyl tyres. As a result of this, several rubber companies were now preparing butyl tyres for qualification testing, and meanwhile, butyl passenger motor-car tyres were beginning to be sold commercially in the United States.

The Esso Petroleum Company, Limited, 36 Queen Anne's-gate, London, S.W.1, which arranged Dr. Sparks's lecture, believe that the potential applications of the new rubber in Great Britain are considerable, not only for tyres but for other domestic and industrial purposes.

ENGINEERING STANDARDS FOR PRESSURE DIE CASTINGS

Many buyers of die castings tend to demand finer tolerances than many applications require, in the mistaken belief that the finest attainable tolerances can be achieved easily in the course of normal production. To bring home to users and potential users of die castings that it is generally unnecessary to specify very fine tolerances for all dimensions in any one casting, and that fine tolerances, usually, need be held on a few dimensions only, the American Die Casting Institute, in 1955, began to issue the first product standards for die castings. These standards gave values for linear tolerances, draft requirements and depths of cored holes, which values were consistent with speedy uninterrupted production, reasonable die and tool life and maintenance costs, and normal inspection and packing charges. The adoption of these standards by industry has given American die casters a common basis for quotations and has also guided designers and engineers towards the most economical use of die castings.

The standards have been devised to show designers what tolerances can be held easily, so that finer ones will not be specified except where they are really needed. Where special requirements in dimensional accuracy are essential, however, it is emphasised that consultations with the die caster will almost certainly result in their adoption.

Realising the benefits of this trend towards standardisation of practice, the Zinc Die Casters Association have prepared and issued a new publication, for use in the United Kingdom, entitled " Engineering Standards for Pressure Die Castings." These standards, which cover zinc and light alloys, have been drawn up by the technical committee of the Zinc Alloy Die Casters Association in collaboration with the American Die Casting Institute and with the assistance and approval of the technical committee of the Light Metal Founders Association. The publication contains 11 pages. Standard 1 deals with linear dimension tolerances; Standards 2 and 3 give the additional tolerances necessary when the dimension is measured across a parting line or is affected by a moving die part. Standard 4 consists of a graph showing the optimum taper for walls, and Standard 5 gives flatness tolerances for plane surfaces. Standard 6 deals with the depth and taper of cored holes of $\frac{1}{4}$ in. diameter and upwards. Standard 7 covers ejector pin marks, and Standard 8 describes the optimum machining stock allowance to avoid excessive tool wear in machining operations.

Copies of the new publication have already been sent to all member firms of the Zinc Alloy Die Casters Association and they are being widely distributed to users and potential users of pressure die castings. The brochure is available gratis on request from the Association, at 34 Berkeley-square, London, W.1.

HYLITE TITANIUM ALLOYS

The range of Hylite titanium alloys manufactured by William Jessop and Sons Limited, Brightside Works, Sheffield, 1, has now been extended to include two new materials. The first, Hylite 15, is a commercially pure titanium, supplied to D.T.D. specifications 5003 and 5023. The second, Hylite 45, a 6 per cent. aluminium, 4 per cent. vanadium alloy, is a high-strength material responding to heat treatment. It is available in the form of sheet as well as rolled-bar forgings.

Management

GIVE ENGINEERS RESPONSIBILITY WHILE THEY'RE YOUNG

Sir Ewart's Practical Experience

Delivering the fourth Graham Clark Lecture to the Institutions of Civil, Mechanical, and Electrical Engineers this week, Sir Ewart Smith, F.R.S., M.A., a deputy chairman of Imperial Chemical Industries, Limited, spoke on "Management and the Engineer." He said that engineers should be given wide experience and responsibility while they were young. Practical experience had taught him three principles—Simplicity, Symmetry and Continuity—which were applicable to both management and engineering. Some extracts from his lecture follow.

Our industrial civilisation has mainly arisen as a result of the invention and work of engineers; have not we, then, as engineers and scientists, a special responsibility to play a more active part in attempting to solve the problems of management and organisation that now confront mankind? The need is to bring the material and psychological realities of life into better harmony, and to secure greater mutual understanding and closer unity of purpose, but without restraint on individual freedom of thought or of expression. As I see it, this is the crucial problem of society; it exists to a greater or lesser extent in every organisation, from the small unit of business up the scale to large industries, to the nation, and indeed to the world as a whole.

As a design engineer, I formed the belief that three valuable principles were those of Simplicity, Symmetry (or Balance), and Continuity; I at least have found it helpful to consider their import in all problems of basic design. As a manager, I have subsequently been forced to the conclusion that these ideas are also applicable to organisational structure, and to the general concepts of management. These thoughts are derived from practical experience, but it may be noted that they are by no means at variance with certain broad aspects of religious thought.

Let me quote a few examples of what I have in mind in connection with these principles. In engineering, an obvious case is the basic simplicity, symmetry and continuity of rotary motion in comparison with reciprocating action. In human affairs and organisation, I believe these same principles can provide good guidance. In management, it is a matter of experience that a good organisational structure is usually one which is simple in form, balanced in its proportions, and clear in its lines of responsibility. Where, for instance, a senior executive has only one, or conversely, very many immediate subordinates, the result is likely to be bad. Then again, in large organisations difficulties will arise unless functional services are symmetrically related to the operating sections which they serve. The need to ensure continuity in the succession of good senior executives is perhaps the first duty of top management.

Specialisation is now so important that there is a danger that it will be regarded as an end in itself. The function of the specialist should be to help, not to control. Equally, general (or line) management cannot do its own job effectively unless it has a good understanding of the work of the specialists and uses them properly. It is not difficult to think of cases where line management has tended to abdicate its proper responsibilities to experts, or specialists, with very detrimental results. That is why it is so desirable for those who are *potential* top managers to be given some first-hand experience of specialist activity on as wide a front as ability and conditions allow, during the earlier stages of their careers.

In order to sort out, develop and use individuals to the best effect, it is important to give them a variety of experience in the early part of their career. This will enable the man himself, and his leaders, to learn in which direction his chief interests and abilities are likely to lie. Those who then proceed to specialisation will have been given a valuable insight into other types of work to which their future activities may well be complementary. For those who are ultimately to undertake wider managerial duties, this background experience will be of great value.

Most engineers like, where possible, to visualise ideas in concrete form and to be clear about terminology. With this in mind, I venture to suggest that the broad relationship of the Arts, the Humanities, Science and Technology can be shown in diagrammatic form, as above. For this purpose, these terms are taken to have the following meanings:

The *Arts* concern the application and appreciation of skill directed to the gratification of taste and the production of what is considered beautiful.

The *Humanities* cover the study of human nature and affairs, and the evolution of moral values.

Science deals with the discovery and correlation of knowledge relative to the unchanging laws of nature.

Technology involves the application of knowledge derived from science to the use and service of man.

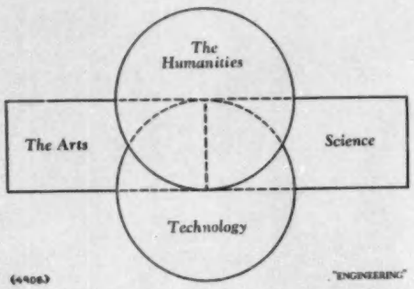
The diagram should be regarded as consisting of the Arts and Sciences as a base on which the Humanities and Technology are superimposed. It brings out clearly that the Arts and Sciences meet, but that the Humanities and Technology overlap each other and, at the same time, both the other disciplines.

The use of rectangles and circles is symbolic. Art is entirely subjective and is a matter of opinion, while Science is completely objective in its nature; on the other hand, the Humanities and Technology each involve *both* the objective and subjective approach. A position on the extreme right or left of the diagram implies complete specialisation; conversely, a point on the overlapping central portion represents a combination of two or more of these four broad aspects of human knowledge and endeavour. Leonard da Vinci would, I submit, be a pre-eminent example of a man standing at the very centre of the diagram, trained and able to operate successfully in any direction. Similarly, it is possible to place the musician, the doctor, the industrial manager, or, in fact, any professional man in his appropriate position.

If we accept the need for a broader approach in education, I am certain that the main change has to take place in the schools rather than in the universities, but the latter hold the key to this change in their scholarship and entrance examinations, and in the length of courses up to the First Degree.

In every field, factual knowledge is now accumulating so fast that we should cease to regard the human mind as the proper or main repository for it. The need is to spend far more time during the whole period of education in teaching people how to use knowledge, and where they can obtain it in codified form, when they require it for their work in later life. We must beware of putting knowledge on the pedestal that should be reserved for understanding.

Most people are clear as to what is meant by physical science, but the term "management" is one of those vague words, like democracy, which can mean very different things to different people. I have already used it many times, and it may, therefore, be helpful to make plain the meaning it is intended to bear in this paper, by giving my own definition.



First, the manager must be ready to organise and plan in a dynamic manner, after analysing all the facts of the situation with which he is faced. Next, he must make the appropriate decisions and exercise executive control over the operations for which he is responsible.

Then, because every manager is concerned with people, he must have regard always to the human and psychological factors, which are of such major importance.

Lastly, but by no means of least importance, is the need for the manager to have a clear idea of purpose, and to state the objectives in terms which his subordinates can fully understand. As external conditions change, he must always be ready to re-examine his own aims and methods. Because progress in the techniques of science and of management is unceasing, the manager has the opportunity to effect continuous improvement. Such a dynamic attitude is a necessity for good management, and I am convinced it can be inculcated in the young far more effectively than is now the case.

My definition attempts to embody these thoughts by saying that management involves "the organisation and control of human activity directed to specific ends."

If we turn now, from management in general, to engineers as managers, it would appear that the basic training and subsequent experience which are normal for the professional engineer should be pre-eminently suited to the development of good managerial qualities. Nevertheless, in spite of these inherent advantages, we must admit, if we are honest with ourselves, that in this country at least, engineers, relative to the contribution which they should be able to make, are not numerically outstanding in senior management of industry or Government.

What, then, are the reasons which now tend to prevent engineers taking a greater part in management? In my view, the main reason lies in our present acute shortage of technologists, which tends to confine them to their own specialist work.

As engineers, we know how vital it is for technical details to be correct, if a successful result is to be achieved. Even when the engineer has risen to a senior position, and as long as he has some direct responsibility for engineering design, manufacture, construction or maintenance, he is still liable, by necessity, and probably by habit of mind also, to concern himself with, at least, some of the knotty minor problems which will inevitably arise.

Once this danger is clearly recognised, it may be minimised and, in effect, eliminated for all who are not out-and-out specialists. What is required first is a broadening of education; second, that all young engineers should be warned of the risk; and finally, that they should be given wide experience and responsibility during their formative years, on the lines already discussed.

The Greeks, in their heyday, proved that Art, scientific philosophy and action can be united to give great results. Our own civilisation can continue successfully only if it achieves a balanced combination of the Humanities and Technology, based on both Science and Art. Our need is for managers who are humanists, but who are able to extend and to use the tools of knowledge which science and technology provide.

Management

Weekly Survey

What Price IATA?

The International Air Transport Association's meetings, like its members, cover the globe. During the last eighteen months, IATA has flown far—from Cannes, by way of Madrid, London and Miami, to Paris. A frequent change of air does not however appear to have brought with it any fresh breezes or a spirit of accommodation. The venue has changed but the problems remain. The airlines, briefly, want to raise fares. They claim, with good reason, that inflationary pressures cannot be met effectively until they have an adequate margin of profit. In 1956, average trading profits of the members of IATA stood at an exiguous 2 per cent. Turnover of the airlines amounted to 3,240 million dollars last year; net operational income did not exceed 50 million dollars, which was just over 1·5 per cent. With results such as these, airlines are justifiably worried about their ability to equip for the future growth of air traffic.

The trouble is that IATA, while it gives the impression of being a world monopoly, is in fact far from autonomous. Any change in fares which members wish to make must be ratified by the government of each country concerned. Thus the power of the IATA chain lies in its weakest link. The chief dissenting government to all moves towards fare increases in the last two years has been that of the United States. At Miami in April, 1957, IATA decided to seek approval to raise all North Atlantic fares by up to 5 per cent. as an " emergency " measure. The Civil Aeronautics Boards, on behalf of the United States government, rejected this request the following month out of tender regard for the interests of United States domestic airlines, although the decision of IATA had been supported by the two major American operators, Trans World Airlines and Pan American Airways. Stalemate seemed inevitable, but the C.A.B. gave out one hope for IATA to break the deadlock. If agreement could be reached on a new low " third-class " fare, the Board would agree to sanction a general increase in first-class and tourist rates. Agreement has now been reached, the compromise being in effect to introduce third-class fares at the expense of the excursion rates and also to raise first-class and tourist fares.

* * *

Investment Plans in E.C.S.C.

The European Coal and Steel Community does not control investments in the industries of its member countries. It does, however, exert what might be called peaceful persuasion to ensure that firms do not all try to do the same things at the same time. The High Authority's recent *Annual Investment Survey* shows a sharp rise in investment in coal and steel. For coal, the High Authority gives 306 million tons as the target for 1960. But current plans are expected to provide only 270 million tons.

Although investment in the mines is to be half as big again as the 1952-56 average, shortage of face workers and reductions in the length of the working week are a brake on expansion. The High Authority takes the view that any really appreciable increase in production will need the sinking of new shafts. A major part of the investment in the coalfields will be in coking plants and pithead power stations.

Plans for the steel industry will bring possible capacity up to 74½ million tons by 1960. The High Authority lays most stress on increasing the output of pig iron, so that expensive imports of scrap can be cut down from around 4 million tons now to 2 million tons a year by 1960. The present investment programmes fall well short of this target.

Investment in rolling mills reached a peak in 1955 and the amount spent now on flat products except plate, is decreasing. The new plans will of course only affect production capacity gradually. The problem of rising scrap prices is one that is taken care of at present by the High Authority's equalisation fund to give an average price based on home and import prices. The cost of this scheme is constantly increasing which makes the long-term plans for improving pig-iron supplies well worth the effort involved.

* * *

Coal Pool needs Nuclear Power

While all eyes have been turned to the proposed European Common Market the other half of the Rome Treaty, Euratom, has attracted far less attention. One reason for this is that Britain has never had any intention of associating with Euratom in any way, but has insisted that co-operation with Europe will be through the O.E.E.C. committee on nuclear energy. The need for the development of nuclear power in the six Euratom countries is emphasised by a report issued by the High Authority of the European Coal and Steel Community. Unless nuclear power is developed the energy imports of the six will have to be increased almost fourfold by 1975. In 1955 total energy requirements were 433 million metric tons coal equivalent. By 1965 this will have risen to 570 million tons and by 1975 to 740 million tons. This means an increase of 83 per cent. over a twenty year period, during which output of coal, hydro-electric power and oil will only rise by 37 per cent. Such an increase in imports presents considerable dangers both from the point of view of security of supplies and of the balance of payments. Even in 1955 the energy production of the six fell short of needs by some 84 million tons coal equivalent, which had to be covered by imports costing over 1,000 million dols. If these risks are to be avoided, it will be necessary to establish a balance between oil and coal imports and at the same time develop nuclear energy as quickly as possible.

* * *

Counterpoint without Harmony

The sight of a boom in consumer goods is a mixed blessing for the engineering industry at the Christmas season. Expenditure on consumer goods continued to rise during the third quarter of 1957, amounting to £1,371 million, or 5 per cent. above the corresponding period of 1956. To some extent, the rise was accounted for by increases in prices and in rents and rates, but other types of expenditure rose as well. Spending on durable household goods for example rose by 10 per cent. to £246 million in the period under review. Taken in conjunction with the level of activity in motor cars, the effect of the credit squeeze has still to be felt by engineering companies manufacturing consumer durable goods. The output continues to expand, as the impact of the Bank rate increase will not be seen until after the seasonal Christmas boom.

While manufacturers of consumer durables are still doing good business, the available indicators on capital equipment are less reassuring, and the same goes for transport, coal and steel. The oil industry has been laying up tankers, coal stocks are at a high level despite some disappointing performance figures by the miners and some sections of the steel industry have less imposing order books than they had six months ago.

It is apparent therefore that the contrast between the consumer goods industries (taking those words in their widest sense) and the capital goods industries is becoming very marked. Provided this contrast lasts for only a limited period of time it is not particularly ominous and, of course, in the fourth quarter of the year outlay on consumer goods includes the Christmas peak shopping season. To some extent, the consumer goods boom is being sustained by hire purchase credit and this will begin to lose its impetus if earnings decline substantially in the capital goods industries. The same phenomenon is occurring in the United States where consumer goods are still buoyant while the capital goods industries are becoming increasingly depressed. If the contrast between the two groups of industries is allowed to last too long, however, the capital goods industries will be bound to pull down the others and the reversal of a trend from recession to expansion will be all the more difficult to bring about. It would be tempting to say that all this could be put right in the April Budget but economic events may be moving too quickly to allow of delay until that date.

* * *

Housing for Productivity

The 10,000th worker's house built in the Coal and Steel Community with the help of High Authority funds has just been handed over. Two main building programmes covering between them 38,000 houses, are now in operation. For the first of these the High Authority raised 25 million dols. on the market in Belgium, France, Germany and Italy. Some 15,000 houses are involved. For the second programme covering 20,000 houses, the High Authority is putting up 15 million dols. and raising a further 30 million dols. on the money markets of the six member countries. All told, the High Authority has now had a hand in financing 26,000 worker's houses, of which 11,000 are being bought by their occupiers.

The lion's share of the new housing is for coal miners, especially in Germany and Belgium. In Belgium, for example, hutted camps that have been a national disgrace for years are being replaced by new housing estates. Good housing is one of the key factors in getting and keeping workers. Many of the new housing estates are at new or expanding mines or steel works with a high level of efficiency. The opportunity of buying a well built nicely designed house is an incentive which can give a considerable stimulus to productivity.

* * *

Sicily Sets the Pace

One of the factors holding up progress in Italy is the complicated system of regional and local government. Sicily, for generations the most backward part of the country, is now beginning to feel the benefits of the more or less self-government it has enjoyed since the war. One big advantage of managing its own affairs is that Sicily has been able to plump for free-enterprise rather than the state-monopolies to develop its resources. Gulf-Oil working on an 80/20 split, perhaps the best terms ever offered an oil company, has invested 50 million dols. in Sicily's oil field and is getting results that make the efforts of ENI the State-owned corporation on the mainland look pretty weak.

But oil is only one side of the story. A new steel works has just been opened at Catania and a big plant to prepare and export orange juice has opened in Messina. An oil refinery to take 45,000 ton tankers has been built at Augusta. Montecatini the Italian chemical giant, has a big potash works at Syracuse. Apart from American oil investments a French chemical firm and German electric power companies are building plants. In spite of all this activity Sicily has a long way to go even before it catches up the rest of Italy. But if the present energy and drive is maintained it should not take many years to do that.

Marketing

CANADA'S WANTS AND FANCIES

Brief Guide to the Market for Engineering Products in Canada

The keenness and breadth of interest aroused by the arrival of the large Canadian purchasing mission in this country surprised all concerned, not least the Canadians themselves. For their first Press conference they had chairs ready for only half those who came and ever since they have been flooded with requests from firms wanting to be visited. Such an effusive welcome must have come as a shock, albeit a pleasant one, for the Dollar Exports Council, the Federation of British Industries and the Board of Trade who have for years struggled with little success to awaken a nation-wide interest in the Canadian market. After only a few days in this country there had been applications from 900 industrialists to meet those members of the mission in corresponding sectors of industry and this number is expected to be doubled.

BACKGROUND OF THE VISIT

Several of the more experienced British exporters of engineering goods had been heard to comment that such missions are somewhat of a waste of time, that they never buy anything and that to sell successfully in Canada needs a great deal more than organised Canadian goodwill. They point to the experience of British firms now established in the Canadian market—there are some 500 in all—and warn that only a better price or quicker delivery or both will persuade the average Canadian businessman to place his order across the Atlantic rather than across the border. In the engineering industry this is generally true. The few exceptions, e.g. Rolls-Royce and their Diesel engines, are firms with world reputation and the ability to invest heavily over a long period to become established suppliers. It is also true that the mission are unlikely to place many orders. Whenever they have been asked about orders the reply has been the same—no definite commitment could be made, there are too many factors such as delivery dates, prices and tendering to be considered.

But one thing is clear. The mission came to see whether or not more of Canada's needs could be met from Britain and among the members are men who genuinely do not know the answer and express surprise whenever they find anything up-to-date. Discussions with them quickly bring home the fact that there is widespread ignorance of what British industry can supply with full confidence that it will compete. Fifty or more people will go back with the knowledge that their Prime Minister's stated policy of buying more from Britain and less from the United States can be achieved. And here we come to the heart of the whole affair.

There is in Canada a political party which does not want the country to become the 49th State. The leader of this party, Mr. Diefenbaker, is now Prime Minister and could not have stated his policy more clearly when he suggested last summer that up to 15 per cent. of Canada's imports could be switched from the United States to the United Kingdom and the Commonwealth: "The heavy influx of United States investment has resulted in some 60 per cent. of our main manufacturing industries, and a large proportion of our mine and oil production, being owned and controlled by United States interests." Mr. Diefenbaker and his party do not like this and are prepared to fight hard to stop the trend. Whether or not it can be stopped—and geography is against it—a great deal of propaganda will go out during the next few months for Canada to buy British and every firm in this country will have an opportunity better than at any time since the war to make headway in Canada. Basically the economic conditions which have promoted the growth of the Canadian dependence on the United States are still there and will continue. After all, 85 per cent. of Canada's industry is within a line parallel to the border with the U.S. and only 200 miles distant.

THE GREAT SWITCH

A switch of 15 per cent. in imports from the United States to the United Kingdom means an increase greater than total British exports to Canada in 1956. This amounted to 485 million dols. compared with 4,167 million dols. imported from the United States. Fifteen per cent. of this vast sum is 625 million cols. or nearly £225 million. But even if this were done the deficit with the United States would remain high—at about 800 million dols. instead of 1,350 million dols. (1956).

Most of the members of the mission are interested in the possibility of buying machinery. The list given in the background notes issued when the mission landed is a fairly wide one: Heavy machinery, textile machinery, equipment for petroleum and gas industries, marine equipment and turbines, electrical generating equipment, construction equipment, foundry equipment, equipment for fishing and food packing industries, coal mining machinery, lumbering and sawmill equipment, and flour milling machinery—it is perhaps more conspicuous for its omissions. Significantly perhaps, these include some of the categories in which there are the largest imports from the United States. Agricultural machinery, and particularly tractors, imported from the United States totalled over 200 million dols. last year, whereas imports from the United Kingdom did not reach 3 million dols. But there are others, including office machinery, and scientific instruments. Yet the inclusion of some categories makes strange reading at the present time: textile machinery is currently in over-supply in Canada and the Canadian textile industries would probably be able and glad to export to Britain, enough modern plant to re-equip many large mills. The inclusion of construction equipment is encouraging, but manufacturers in Britain should not overlook the fact that the methods of building in Canada (where labour is extremely costly) are very different from those used in this country. It is not easy, and may not be desirable to design a range of products especially for the Canadian market, though even this can pay dividends.

It is not possible to decide whether or not a firm's products are likely to be in demand in Canada, and therefore we print on this page the list of items prepared by the Federation of British Industries on behalf of the Dollar Exports Council. Only items of plant, equipment and machinery are given, but this represents all but six items in the full list. It suggests, and this was confirmed by the leaders of the mission, that the bulk of the switch in imports to this country must be based on engineering products.

This list does not include all major items imported by Canada from Britain: cars, for example, are not included. It does, however, include all principal items imported from the United States.

After only a few days in this country most members of the mission would exclaim—"Gee,

IMPORTS INTO CANADA FROM U.K. AND U.S.A. FOR 12 MONTHS ENDING DECEMBER 1956; VALUE IN THOUSANDS OF CANADIAN DOLLARS.

Class and number	U.K.	U.S.A.
AGRICULTURAL EQUIPMENT		
5302 Harvesters and parts	8	2,903
5305 Mowing machines and parts	10	2,612
5306 Potato diggers, planters parts	4	503
5321 Cultivators, scufflers and parts	61	2,937
5322 Drills, seeders and parts	3	1,192
5332 Harvester combines and parts	74	15,110
5346 Hay presses and parts	174	11,654
5356 Traction ditching machines and parts	15	1,412
5357 Tractors, internal combustion	2,198	106,529
5358 Tractors parts and accessories	618	49,896
BALL AND ROLLER BEARINGS		
5680 Roller bearings and parts	621	6,641
5682 Ball and roller bearings for automobiles	126	3,466
5683 Balls, roller for bearings	1	594
5685 Ball bearings and parts n.o.p.	452	5,403
COMPRESSORS		
5521 Air compressing machinery and parts	654	12,932
CONTRACTORS' PLANT		
5518 Shovels, power, not made in Canada	4	8,237
5519 Shovels, power, kind made in Canada	1,073	15,527
5520 Shovels, power, parts of	210	9,097
5530 Concrete mixers and parts	35	1,633
5560 Road-making machinery and parts	130	8,249
5561 Trench and ditch machinery and parts	29	176
5585 Bulldozers, earthmovers and parts	440	20,472
5588 Stone crushing machines and parts	41	5,326
ELECTRICAL GOODS		
4171 Electrical insulating press board	20	484
4210 Electric cable insulating paper	14	1,636
4237 Cable insulating paper, n.o.p.	101	200
5537 Refrigerating machinery and parts	174	7,769
5582 Air conditioning apparatus, n.o.p.	329	11,399
6144 Dynamos, generators and parts, n.o.p.	2,784	12,593
6154 Motors, electric, under 10 dols.	31	496
6155 Motors, electric, n.o.p., and parts	2,754	16,731
6161 Switches, switchboards and parts	2,525	13,814
6165 Transformers and parts, n.o.p.	1,935	7,027
6171 Electric precision instruments	601	8,451
7055 Insulators, electric porcelain	135	828
ENGINEERING PRODUCTS		
5243 Engines, Diesel and semi-Diesel	3,851	20,270
5244 Engines, gas, marine and parts	35	1,076
5246 Engines, fishing-boat, and parts	4	142
5548 Metal rolling mill machinery and parts	34	4,572
5552 Cranes, etc., not made in Canada	236	3,285
5553 Cranes, etc., kind made in Canada	602	7,604
5556 Paper mill machines and parts	1,187	11,351
5572 Water meters, n.o.p., and parts	20	65
5573 Water turbines and parts	234	452
5584 Bottling machines and parts	32	3,674
5587 Power jacks and parts	49	1,786
5730 Industrial furnaces and parts	135	3,019
FOOD MACHINERY		
5290 Cream separator, parts	7	77
5292 Cream separators	3	787
5295 Milking machines and parts	4	1,901
5295 Pasteurisers, dairy, and parts	239	335
5296 Power dairy machines	90	1,718
5522 Bakery machinery and parts	112	3,226
5536 Fish preparing machines and parts	4	88
5726 Ovens, commercial, bakery	25	408
MACHINE TOOLS		
5542 Metal drilling machines and parts	885	3,915
5543 Metal grinding machines and parts	848	5,712
5544 Metal working lathes and parts	1,944	4,805
5545 Metal milling machines and parts	531	2,641
5546 Metal working planes and parts	47	111
5547 Metal working presses and parts	443	6,882
5549 Metal shapers, slotters and parts	283	1,655
MECHANICAL HANDLING		
5586 Conveying equipment and parts	536	10,871
5672 Factory, warehouse trucks, motor	83	4,555
5674 Fork lift trucks and parts	297	10,251
MINING EQUIPMENT		
5471 Mine loading machinery conveyors	2,922	14,635
5473 Machinery, alluvial mining	0·25	1,289
5477 Ore crushers, Grinding mills	79	4,435
5487 Coal cutters, Augers, Drills	11	152
5481 Rock drills and parts	149	1,887
5529 Coal-handling machinery and parts	2	112
5531 Rock drill bits	9	788
6258 Tungsten carbide inserts	0·25	572
6259 Tungsten carbide tips, blanks	4	283
OFFICE EQUIPMENT		
5500 Adding machines and parts	65	1,916
5501 Book-keeping machines and parts	571	13,550
5502 Cash registers	0·25	223
5503 Cash register parts		1,816
5504 Dictating machines	783	1,741
5505 Typewriters	2,046	870
5506 Typewriter parts	145	4,419
5692 Metal furniture	382	8,610
SCIENTIFIC INSTRUMENTS		
9129 Thermometers	75	1,197
9130 Apparatus X-ray	41	3,302
9146 Optical and photographic instruments	500	3,756
9150 Surgical instruments	310	4,389

if this is what the old country can do, why for Pete's sake didn't you tell us?" Talks with individual members of the mission revealed staggering ignorance of British industry. The explanation is simple enough; the slight show of publicity we have attempted as a country, or as an industry, has been completely lost in the hard glare of United States and Canadian spotlights.

With faster air travel on the way an era is opening up of relationships in a world where the advantage of proximity enjoyed by a large section of United States industry will be less real. Already progressive firms have been able to send their senior executives and application engineers at a moment's notice, and where necessary have flown spares over, but the idea that the United States is only a car ride away and that you have only to whistle to get a maintenance man over whereas Britain is thousands of miles away, dies hard. It will take time and cost a great deal to remove this feeling.

FACING FACTS

As in most markets, the three major factors in successful selling are the ability to compete (in price and performance), the ability to deliver when required and the ability to service the products when they have been sold. The earlier comment on salesmanship applies here also. When British firms have such advantages they have been slow to let Canadians know. The Canadian buys mainly on price. That is why the Board of Trade, the F.B.I. and the D.E.C. selected some of the most progressive and successful firms for the mission's visit. So far, in most of the products on the list we publish, British prices have been highly competitive. Wherever the labour content of an article is high and the tool costs low, British prices are lower, often substantially so.

Delivery is a sore point with many Canadians who have suffered in the past. Their needs are no different from any other nation, except that with the United States next door the sales barometer reads high and they are accustomed to being served on the dot and therefore tend to order only at the last minute.

Servicing needs are psychologically very prominent. Canadians have unfortunately suffered from poor spares delivery after the war, from the United States as well as the United Kingdom, but they remember us best and stress our remoteness as a factor. Too many firms attempted to sell in Canada and then gave up the attempt. Their failure to go ahead with the setting up of comprehensive servicing arrangements and sometimes their failure to service what they had sold did considerable harm to British industry's prospects. The leaders of the mission, Mr. Gordon Churchill and Mr. J. S. Duncan, both emphasised that they wanted the smaller British company to supply Canada as well as the large.

STRENGTH OF THE OPPOSITION

The strength of the United States in Canada is based on very large investment in manufacturing and extractive industries. In the nine years 1946 to 1954 some 4,400 million dols. were invested by non-resident United States citizens accounting for nearly 93 per cent. of total non-resident investment in Canada from all sources.

It is as well to be aware of the strength of the opposition, since the task on hand is to take over 15 per cent. of United States exports to Canada. The strength of the United States is also its weakness since it is the basic reason for Mr. Diefenbaker's aggressive pro-British policy. There are about 500 such firms now active in the Canadian market through branches, subsidiaries and other established representation. It is assumed that they will do even better under the period of official encouragement now beginning. But the answer to Canada's wish, if the Diefenbaker government's policy of becoming less dependent on the United States can be so interpreted, is for another 500 firms to join them.

Research and Development

PHYSICAL RESEARCH APPLIED TO MACHINE DESIGN

High-Pressure Fluid Transmissions

*By Dr. Hans Thoma**

In London last Friday the James Clayton Lecture, on "High-Pressure Hydraulic Power Transmissions," was given before the Institution of Mechanical Engineers by Dr. Hans Thoma. After analysing the differences between hydrokinetic (centrifugal pump and turbine drive) and hydrostatic (piston pump and piston motor drive) transmissions, Dr. Thoma described some of the development problems of high-pressure hydrostatic power transmission, and how their solution has been influenced by fundamental physical science. We give below extracts from this part of the paper, together with a brief summary of some applications of the system, with which Dr. Thoma concluded his lecture.

In hydrostatic power transmission, relatively small high-speed piston-engines work in conjunction with one another in a fluid circuit, which generally contains normal engine oil; one unit acts as a piston pump, and the other as a piston engine, using fluid at high pressure and comparatively low velocity. The cylinders are arranged in a rotating barrel with their axes parallel to the axis of rotation. The cylinders can be compact and close together, thus keeping the outside diameter of the barrel small, as is required for high speed. Instead of a swash-plate with its universal joint rotating at an angle to the main driving shaft, a driving flange is fixed on the shaft to which the pistons are connected through ball-and-socket-jointed connecting rods. Fig. 1 shows such an arrangement, which was put on to the market about 25 years ago by two German firms, and later adopted by Vickers Inc. of Detroit. With this arrangement the rotating cylinder body can be swung with reference to the driving flange fixed on the driving shaft, the piston stroke being approximately proportional to the sine of the angle of inclination. The design shown in Fig. 1 thus represents a type of piston engine with a continuously variable piston stroke.

A positive fluid-distribution device, on the outer end face of the cylinder barrel, consists of a stationary timing plate, which has two kidney-shaped ports (Fig. 2), and is fixed to the swinging body in close pressure-tight contact with the corresponding end face of the rotating cylinder barrel (Fig. 3). In this end face there is a port for each cylinder. It is necessary that the rotating cylinder barrel shall be carried round with the driving shaft. This is effected, in the design shown in Fig. 1, by a universal joint between the driving shaft and the cylinder block fitting into a recess in the shaft and a cut-away in the block. In the latest designs this universal joint is eliminated, and the cylinder block is carried round by the individual connecting rods—a method which is very robust and practically free from wear.

* Consultant; formerly professor at the Technische Hochschule, Karlsruhe.

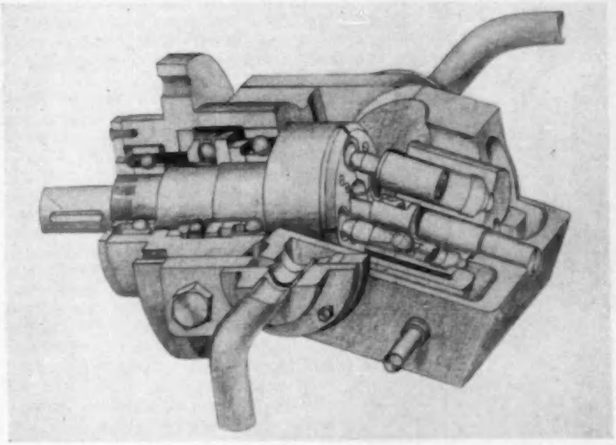


Fig. 1 An early type of hydrostatic transmission with an inclinable cylinder barrel.

DISTRIBUTOR FACE WEAR

At first sight it appears easy to obtain good sealing of the distributor

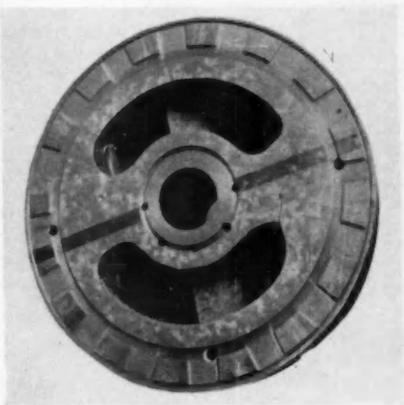


Fig. 2 Fixed timing plate of the cylinder barrel shown in Fig. 3.

Fig. 3 Cylinder barrel for a 400 horse-power (continuous) hydrostatic transmission.

Continuing

Research and Development

faces, because of self-sealing of the faces. It is only necessary to ensure that the whole cylinder barrel is pressed by hydraulic forces against the stationary timing plate.

This self-sealing property, however, easily leads to undesirable wear of the sealing parts, due to partial or transient metallic contact between the sliding faces. Provided that they run at only moderate speeds, it is true, the working surfaces do not always run so hot as to entail their complete destruction, but the slow wear without actual breakdown is harmful because it causes gradually increasing roughness of the sealing faces, and hence leakage losses, which may become quite troublesome. Sealing and sliding faces which do not allow any pressure oil to get through are therefore not suitable for continuous running. There should at all times and at all points be a thin oil film between the accurately-mated sealing and running faces. The properties of the sealing and sliding surfaces, and in particular the features of the distributor, therefore had to be thoroughly investigated.

A large part of the piston thrust can be transmitted from the cylinder barrel to the timing plate through the fluid pressure in the timing ports. Unfortunately it is not possible to balance completely the longitudinal forces exerted on the cylinder barrel, and it is therefore essential to design the hydraulic unit for a certain excess thrust of the cylinder barrel and, for safety, to provide a large-capacity thrust bearing.

One of the earlier methods was to provide islands or pads on the timing plate, as illustrated in Fig. 2. These islands receive oil by leakage from the distributing ports, and the outer land is a retaining ring which prevents the oil from flowing away too rapidly. The excess oil is discharged through the small ports between the pads. These simple pads have a very limited load-carrying capacity wnen used at high speed. Better results are obtained by inclining the bearing face of the pads. A still better solution proposed by Michell is to allow the pads to tilt about a suitable axis and to adjust the inclination themselves. This arrangement has the great advantage of being insensitive to small amounts of wear. A 250-ton Michell thrust bearing has given 30 years' service without alteration, at a sliding velocity of 36 ft. per sec. and a loading of 370 lb. per sq. in. Substantially higher loading is not possible because then the pads overheat, especially at the trailing edge.

HYDROCALORIC THEORY

Research on sliding friction has given rise to the so-called hydrocaloric theory of thin high-speed sliding oil-films. According to this theory it is possible, in the range of higher sliding velocities of about 20 ft. per sec. and upward, to calculate the temperature rise in the oil film which has to be dissipated mainly by the flow of oil in the oil film itself. If the temperature rise in the flowing oil film is limited to about 50 deg. C. it is also possible to determine the loads which can be employed with good reliability. This gives definite relationships for the minimum permissible oil-film thickness and demonstrates the possibility of constructing wear-free thrust-bearings for considerably higher loadings in large hydraulic transmissions by forcing high-pressure oil, dosed, through calibrated restrictions, into corresponding fields in the bearing surface.

Fig. 4 shows a pressure-lubricated thrust-bearing arranged concentrically around the kidney-shaped ports of a timing plate. High-pressure oil is led in through the holes 1 and 2 from the high-pressure side of the drive unit. The annular groove 3 serves to regulate the dosage. It is interrupted by numerous indentations 4, which assist the spreading of the oil pressure in the bearing surface, and increase the throttling effect by repeated separation of the jet. The oil-pressure inlet ports are not drilled directly into the annular groove, but are each shut off from it by a short land, 5 and 6. These lands are bridged over during only brief intervals by several small pockets bored in the rotating valve face, so that a limited quantity of oil is momentarily injected into the annular groove. The purpose of this device is further to reduce the quantity of high-pressure oil admitted through the annular groove into the bearing surfaces and consumed in the positive formation of the oil film. The oil groove is sufficiently deep that any wear which might occur in the distributor faces would not impair the reliability.

In this way it has proved possible to regulate the sliding faces to give a definite gap between them, or a definite oil-film thickness, by means of oil-pressure fields produced in the distributor face itself. This arrangement is as suitable for high speeds, which require a thicker oil film, as for high working pressures. The load-carrying capacity of the distributor faces is finally limited only by the elastic distortion of the faces, which can easily be made very rigid.

The practical result of applying the hydrocaloric oil-film theory is that slip values are obtained which are not only quite low but can also be repeated at completely constant level in series production. For large units working at pressures of 1,500 to 3,000 lb. per sq. in., the slip values are of the order of 1½ to 3 per cent. of the maximum circulation or maximum speed. In comparison with older distributor faces still running without positively-ensured oil-film formation, not only a reduction of the total pressure-oil consumption has been obtained, but also a considerable reduction of the surface friction. A further important result is that such distributor faces show no deterioration whatever after many years of service.

The hydrocaloric theory can, of course, be applied only to oil films sliding at speeds of about 20 ft. per sec. or more, because only with such films does the assumption hold good that the removal of heat through the metallic bearing surfaces can be neglected. At such sliding velocities, and with the dimensions which are of interest here, the oil-film thickness has to be 10 microns or more, and not merely somewhat greater than the roughness of the bearing surfaces.

It is essential to prevent the entry of foreign bodies which exceed the dimensions of the sealing and running clearance. For this reason a magnetic filter was constructed in which very strong and strongly-convergent fields are employed. Fig. 5 shows the magnetic element of such a filter, consisting of a brass tube containing the magnetic system. The smooth surface reduces turbulence which impairs the filtering; it also facilitates cleaning and emptying the filter. Turbulence is further reduced by the ribs on the magnetic element, as well as by occasional perforations in the outer tube; at the same time this blocks the flow of fluid through those parts of the magnetic field which are ineffective. Surprisingly enough, even fibrous materials and abraded particles of bronze are retained in the

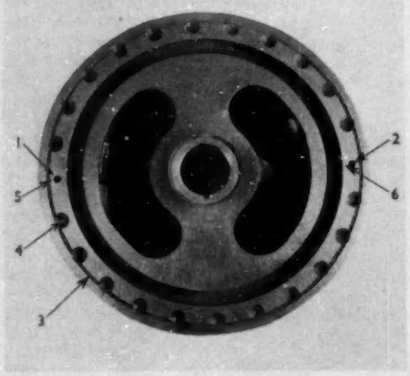


Fig. 4 Fixed timing plate with high-pressure-lubricated thrust bearing.

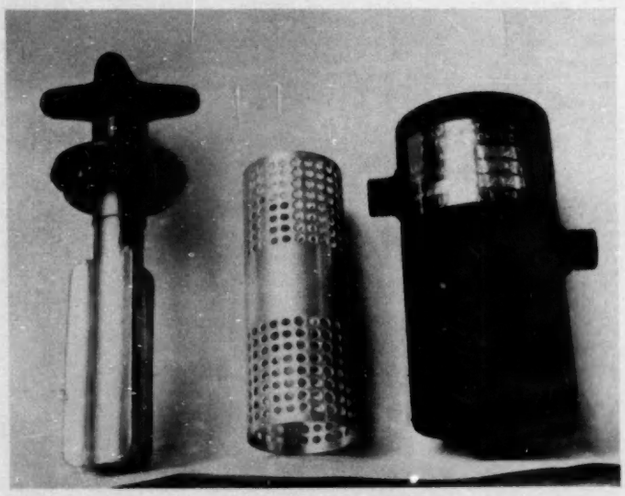
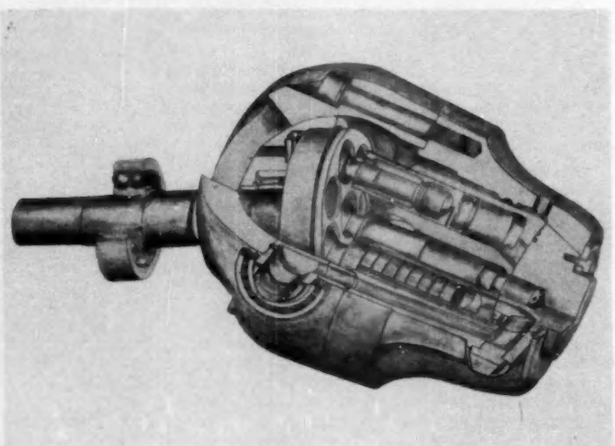


Fig. 5 A magnetic filter unit for the high-pressure oil system which effectively removes fibrous materials and abraded bronze particles, as well as ferrous metals.

Fig. 6 (below) A high-pressure transmission unit designed to give an acceptable noise output.



magnetic field. Microscopic investigation at once reveals the reason for this phenomenon. Fibres are always found to have iron and hammer-blow particles adhering to them, and abraded fragments of bronze generally have a thin coating of iron welded on to them. This proves how fundamental are the classic findings of Bowden and Ridler for physical consideration of bearing problems; they found that, even in apparently cool-running bearings, high temperatures, corresponding to the melting or welding temperature of the metals that are employed, occur in microscopic areas.

ACOUSTIC CONSIDERATIONS

If the considerations set forth above are applied to one of the older types of drive such as that shown in Fig. 1, it is possible to construct a very powerful, compact and lightweight drive that will stand up to high speed and high working pressures. Unfortunately, it makes an unbearably loud noise. The whole design of these older drives therefore had to be modified according to the laws of acoustics which, as a rule, are known to very few who are not physicists, and are still regrettably seldom applied to machine construction. Fig. 6 shows the resulting design of drive which is usual to-day. The swinging body has assumed the form of a pear-shaped casing which encloses, and positively supports, the bearing on the driving flange from the rear, usually at the large visible spherical surface. This gives an extremely rigid connection between the interacting parts, namely, the cylinder barrel with its distributor on the one hand and the driving flange fixed to the shaft with its bearing on the other. This greatly reduces the noise, so that now it causes no trouble.

GOOD REGULATING CHARACTERISTICS

Turning now to some applications utilising the good regulating properties which are characteristic of the high-pressure drive: in an Italian State Railways Diesel locomotive which is equipped with a 350-h.p. Diesel engine from which the drive is transferred to a jackshaft through a hydrostatic transmission, no critical speed occurs with the jackshaft transmission up to the maximum speed of 60 km. per hour. Critical speeds are a characteristic feature of jackshaft transmissions driven by electric motors, whereas the hydraulic (and accordingly damped) coupling of the jackshaft transmission to the inertia mass of the Diesel engine will aperiodically absorb and damp any impulses which may occur. Moreover, the infinitely-variable hydrostatic transmission gives very accurate manoeuvrability, and enables full use to be made of the adhesion weight.

In a 500 h.p. mine hoist with hydrostatic transmission, it has, surprisingly enough, been found that the life of the winding cables is about twice as long as when use is made of the three-phase motors with regulating starting gear which were previously used. This may be due to the small mass of the secondary unit which drives the hoist, together with its elastic and damped coupling to the three-phase mains. In this respect the hydraulic winding-gear drive is similar to the jackshaft transmission.

Hydrostatic transmission has also been applied to the hoisting gear of a dock crane, enabling fragile goods to be set down without shocks; to marine transmissions; and to rotary snow ploughs. Hydrostatic transmission quite materially improves the steering of tracked vehicles, especially since the small mass of the secondary unit permits rapid, continuous, and infinitely-variable differences in the speeds of the tracks—a thing which cannot be obtained with the usual method of steering by means of declutching and mechanical braking of the tracks.

A hydrostatic transmission has been built into each rolling stand of a stretching and reducing rolling mill, to provide the very accurate adjustability of the peripheral speeds of the individual stands of rolls that is required.

This transmission has to maintain constant peripheral speeds within an accuracy of at least 1 per cent. even during the loading shocks which occur when the individual tubes enter into or pass out of engagement. The mill described is capable of reducing inserted tubes with an internal diameter of 3 in. and a length of 120 ft. to $\frac{1}{2}$ in. internal diameter, and at the same time of reducing the wall thickness to half its former value.

METAL FILMS AND FLUID FLOW

A distribution of matter of interest to the research worker, and promising to be of increasing practical importance, is the thin film. Thin metallic films provide the electrical engineer with new resistive elements; the removal of thin films of grease, and the deposition of thin films of fluorescer, are problems that occupy the detergent chemist. And, as the article preceding this one demonstrates, thin films of oil are of great importance in friction reduction.

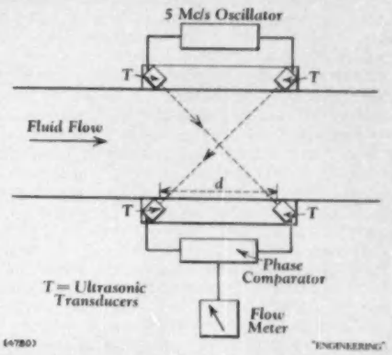
Recently the British Scientific Instrument Research Association, South Hill, Elmstead Woods, Kent, held several open days. Among their exhibits they showed various aspects of their programme of research into thin films. A practical application that was displayed was the use of a thin metallic coating on a transparent cockpit cover. The coating reflects infra-red radiation well and has an optical transparency of 75 per cent. Thus it offers useful protection from solar radiation. In addition the coating has a low electrical resistance and when connected to a low-voltage supply can dissipate sufficient heat for de-icing. Three layers make up the coating—two films of bismuth oxide sandwich and one of gold.

Early attempts to use a pure gold film were unsatisfactory as the film had poor adhesion, was very soft, had a high resistance, and bad light transmission properties. The addition of films of bismuth oxide resulted in considerable improvement. Electrical loading up to 1 watt per sq. cm. is now possible and the resistance of the gold film is close to that of the bulk metal.

An example was displayed of such a coating, produced in a 36-in. plant manufactured by Edwards High Vacuum Limited, Crawley, Sussex. The apparatus employs one or more pairs of sector cathodes mounted under a plane rotary work holder. Each pair of electrodes can be connected in turn to an a.c. high tension supply. During sputtering each sector functions alternately as an emitting cathode, and a uniform distribution is obtained by virtue of the rotary work holder. In addition the equipment has been fitted with an offset vapour source, so that multilayer evaporated and sputtered films can be produced in one cycle.

The Association are investigating the role of the bismuth oxide by measuring the release in energy when gold is condensed *in vacuo*. Bismuth oxide is sputtered on to one half of a nitrocellulose substrate and gold is then condensed on both halves. The different temperature rises of the two parts of the substrate are measures of the binding energies of the gold films. Temperatures are measured with thermocouples of very low heat capacity, formed by depositing overlapping films of antimony and bismuth on the back of the substrate.

One of the unknown factors in the study of thin films is the mechanism by which a metal deposit attaches itself to a glass surface. Experiments are being carried out to investigate the vacuum deposition of metals in atmospheres other than air. Pressures of the order of 10^{-5} mm. are used. Some preliminary work in this field has suggested that chemical bonds may be formed between the metal and the glass, with oxygen atoms playing an intermediate role. It is possible that when a metal is evaporated *in vacuo* small quantities of the oxide are formed by direct union, and molecules of this oxide may bond to the silica tetrahedra in the glass structure. Alternatively it can be postulated that metal atoms could replace hydrogen atoms in the hydroxyl groups which are always formed on a glass surface by interaction with moisture. It has been found that films evaporated in atmospheres of oxygen, sulphur, or selenium are much more adherent to glass than a film evaporated in air. Experiments are also being carried out to explore the conditions which affect the production of gold films by chemical reaction.



The ultrasonic flowmeter compares the transit times of waves moving with the fluid flow with those moving against the flow.

Thin metallic films on glass may be used as resistance thermometers. A method of attaching conducting leads to the ends of the film has been developed to enable the thermometer to be used at temperatures near the softening point of the glass. Terminals of silver foil are attached to the glass support by means of a silver paste. When the paste is fired it adheres strongly to the glass and the foil. The silver terminals overlap gold electrodes previously fired on to the glass, and the metal resistance element is deposited by thermal evaporation *in vacuo* so that its ends also overlap the gold electrodes. The mechanical strength of the joint is such that, even near the softening temperature of the glass, failure occurs in the silver foil rather than at the joint.

MEASURING FLUID FLOW

Turning now to another aspect of B.S.I.R.A.'s activities—flow measurement—two types of flowmeter were shown: ultrasonic and electromagnetic. The latter relies for its operation on the principle that a conductor moving in a magnetic field develops a potential across its length. The fluid constitutes the conductor and two terminals in opposite walls of the tube carrying the fluid measure the potential across it at the point where it flows through a perpendicular magnetic field. It is essential that the measuring instrument, connected to the terminals in the fluid, has an internal resistance that is effectively infinite compared to that of the fluid. This limits the range of fluids with which the electromagnetic flowmeter can be used.

The equipment shown in the laboratories operated satisfactorily with water and ethylene glycol. The latter has a conductivity of about 1 micro-ohm per cm. and this is about the lowest conductivity that can be tolerated in the equipment. An input impedance of 1,000 megohm has been achieved in the detector by the use of a cathode-follower input with a pentode in the cathode circuit and heavy overall feedback. For any individual apparatus the voltage appearing across the electrodes is directly proportional to the velocity of flow of the liquid. Increasing the diameter of the pipe and the strength of the magnetic field results in an increase in the generated voltage.

An ultrasonic flowmeter has applications where obstruction to the flow is not permissible, and where the measuring elements must be isolated from the fluid. A diagram of the experimental model produced in the laboratories is shown above. The flowmeter compares the

Continuing
Research and Development

transit times of ultrasonic waves travelling with and against the stream. This is done by comparing the phase of the two sets of waves. The difference in phase angle is directly proportional to the velocity of flow of the fluid. It is also proportional to the frequency of the ultrasonic waves and the distance *d*. Unfortunately the phase angle is inversely proportional to the square of the velocity of sound in the medium so that the present equipment has to be recalibrated for different media. In addition, as the velocity of sound varies with temperature, the measurements are very sensitive to temperature errors. It is hoped that a system will be produced that is independent of the velocity of sound. The model exhibited gave a full scale reading at 20 gall. per min. in a 2-in. pipe.

In all there were about 70 exhibits showing work from the departments of physics, chemistry, electricity, electronics, mechanics, optics and photography. The work of the Association includes long-term research, applied research, technical assistance, and a certain amount of sponsored research. In addition there is an information service.

EXTENDING THE USE OF PRINTED CIRCUITS

Printed circuits are generally known as a replacement for conventional wired circuits. In this application they eliminate the wiring errors of human operators and produce a more reliable circuit. Economically their advantage is marginal except where large quantities and extensive mechanisation are involved.

However, printed circuits find application at microwave frequencies where they can replace waveguide components. At such frequencies they are referred to as strip transmission lines. The radio frequency losses of the printed circuit are slightly higher than those of the waveguide, but the operating bandwidth is usually larger. Generally the printed circuits are cheaper than waveguides and their use is economically worthwhile even when the quantities involved are numbered in dozens.

At the extremely high frequencies of operation —about 5,000 Mc/s—the printed circuits depend on the interaction between strips of high-conductivity material printed on either side of a thin sheet of dielectric. This is in contrast to printed circuits operating at lower frequencies where the circuit is often printed on one side of the sheet only and serves solely as a direct electrical connection.

Mr. J. M. C. Dukes in a paper " The Application of Printed Circuit Techniques to the Design of Microwave Components," gives details of a transmitter-receiver unit, for 3,800-4,200 Mc/s, using strip transmission lines. The paper is to be republished in 1958 in vol. 105, part B, of the *Proceedings of the Institution of Electrical Engineers*. Mr. Dukes—he is with Standard Telecommunication Laboratories Limited—points out that the receiver occupies about two-thirds of the volume of the standard unit that uses waveguide techniques, is lighter, and can be set up more quickly. A further advantage, common to all printed circuits, is the potentially high order of reproducibility in quantity manufacture.

ABORIGINAL RECORDING

Several four-inch Edison wax recordings of Australian Aboriginal tribal songs made by Sir Baldwin Spencer about 1901 were found recently in South Australia. Adelaide University were unable to find a machine in their State able to play the recordings, but the Museum of Applied Arts and Sciences, Sydney, had a suitable phonograph, which was placed at the University's disposal. The Australian Broadcasting Commission was able to make new, excellent recordings for the University with the aid of the phonograph.

Book Reviews

TEMPERATURE TROUBLES

Thermal Stresses: With Applications to Airplanes, Missiles, Turbines, and Nuclear Reactors. By B. E. GATEWOOD. *McGraw-Hill Book Company Incorporated, 330 West 42nd-street, New York 36, N.Y., U.S.A.* (7.50 dols.); and *McGraw-Hill Publishing Company, Limited, 95 Farringdon-street, London, E.C.4.* (56*s.* 6*d.*)

This is a new addition to the series " McGraw-Hill Publications in Aeronautical Science," for which Professor J. C. Hunsaker is consulting editor; the author is " Research Consultant and Research Professor, Air Force Institute of Technology, Wright-Patterson Air Force Base, Ohio "; most of the particular problems discussed have aeronautical applications, and many of the hundreds of authorities cited have aeronautical affiliations.

There can be no doubt that aeronautical engineers have recently become intensely interested in thermal problems; nor can there be any doubt that the " heat barrier " is behind all this interest, or rather in front of it. Stagnation temperatures have been predicted—and measured —which rise almost astronomically as flight speeds, or wind tunnel velocities, increase beyond the sound barrier, and heat inputs measured in hundreds of kilowatts a square foot are nonchalantly canvassed in the literature. In comparison, the thermal problems of subsonic aircraft seem inconsiderable if not trivial; it is easy to see why stress-men were never much disconcerted by, for example, the diffusion of heat from a hot engine or a heated cabin to an airframe in an ambient temperature of 40 deg. below zero, nor by the converse problem of diffusion into a cool fuel tank from an airframe standing under a tropical sun.

Many of the basic problems caused by kinetic heating are of the same kind as those encountered hitherto, but they are of a very different order of magnitude. Thermal effects in the design of aircraft and missiles are now assuming the dimensions of other loading actions, and in some design problems the thermal issues may be overriding. Although the fundamental principles of heat-transfer theory and thermal stress analysis have long been established, particular problems can usually be more expeditiously solved if reference to a library of case-law is available. For this reason alone the aeronautical engineer, confronted with a " heat-barrier " or other thermal problem, will prefer to turn to a book such as this rather than to one of the many classical treatises.

There is a familiar type of text-book in which master equations are established, from which solutions fall out almost mechanically after inserting relevant boundary conditions and pulling the appropriate analytical strings. Here we are not concerned with the energy equations, stress functions, and tensor notations, which in some other contexts have been successfully used to promote clarity and facilitate understanding. In this field the advantages of such methods are questionable, and here the author very properly uses an engineering rather than a mathematical approach; elementary methods are applied to the solution of simple problems, and the more complicated problems are tackled in logical sequence. Not many of these more complicated problems are literally solved in the text; for this is a slim volume running to a little over two hundred pages, and in this field it is only the simplest physical problems that can be concisely analysed.

For this reason, many of the more interesting special problems are discussed by reference to the original analysis, with reproduction of a set of typical results. An example of this method of presentation is the reproduction of three half-page diagrams, showing thermal stresses in plates, with an acknowledgment to J. S. Przemieniecki of the Bristol Aeroplane Company Limited. Among other British authorities cited are W. H. Horton and E. W. Parkes, but the weight of American authority, all recent work, is greater by a factor of something like 50 to 1. This American predominance, which is a fair reflection of the weight of authority available, is no doubt due to the scale of support of academic research by United States Government agencies. This, as Dr. Clark B. Millikan recently emphasised, in the 45th Wilbur Wright Memorial Lecture, currently amounts to nearly 20 million dols. a year for " aeronautical and closely related fields."

It is natural that about half the book should be concerned with the determination of temperatures and temperature-gradients, for these are the origin of thermal stress. But there can be no thermal stress without the material characteristic of thermal expansion; moreover, thermal stresses are relieved by elastic distortion and limited by plastic flow. Hence material properties are much more important in this connection than in the analysis of mechanical stresses. Discussion of such topics accounts for the other half of the book. Here again the author's method is to outline the field rather than to exhaust it, and readers interested in special problems, such as thermal buckling or thermal fatigue, may soon find that they have to delve deeper and consult the references.

The book is excellently produced, with a good subject-index, but it lacks an author-index. A commendable feature of the typography is the omission of the full point after abbreviations for the names of units, including the use of Btu for British Thermal Unit. This convention goes further than the current British Standards recommendation, and its effect is to make the dimensions of a heat transfer coefficient appear almost elegant in the form Btu/(hr) (ft²) (°F).

Dr. Gatewood has completed his task in an admirably workmanlike manner, and his book may be expected to become indispensable to everyone concerned with thermal stresses, especially in connection with aircraft and missiles.

HEAT AND VENTILATION

Air Conditioning. By WILLIS R. WOOLRICH and WILLIS R. WOOLRICH, JR. *The Ronald Press Company, 15 East 26th-street, New York 10, N.Y., U.S.A.* (7.50 dols.)

During a recent visit to this country a well-known American consulting engineer said that air conditioning is a way of life. The phenomenal growth of the air conditioning industry in the United States over the past decade or so and the general acceptance of air conditioning as a necessity in homes, offices, factories and hotels there certainly justifies the view that, at least, it is now part of the American way of life. How long it will be before air conditioning in the tropical and sub-tropical areas of the rest of the world will become as common as central heating in the Northern Hemisphere is perhaps a matter for conjecture but that the time will come in the comparatively near future is beyond question.

As the authors of this book state, the thermodynamic concepts of Charles, Boyle and Dalton and of various British experimenters and investigators provided the basis upon which Carrier and his colleagues developed the present-day psychrometric concepts. The work of the British physiologists in the field of environmental hygiene, in particular, occupies a position of major importance in the literature of air conditioning. But in recent times most of the important developments in the engineering aspects of air conditioning have originated in the United States, and therefore an engineer looks at a new American text-book on the subject in the expectation that the latest information on design and operational experience of the more recent and interesting installations will be

fully documented. In this respect the book is disappointing. The professional engineer will look in vain for design studies of the high-velocity, high-pressure systems which have been operating for years in the United States. Medium-pressure systems with fan-coil units and high-pressure double-duct systems with mixed-air diffusers are not mentioned at all in the chapter dealing with air distribution, which seems to be concerned only with the somewhat crude warm-air-furnace heating arrangements for houses. Major problems in design of air-conditioning systems, such as noise reduction and the control of temperature and humidity, receive scant mention.

The extremely difficult task of assessing the appropriate design criteria for the summer cooling load is hardly dealt with at all. While the cooling design load receives only some six or seven pages of text. Half as much space again has been devoted to dealing with the winter-heating design load. The sections dealing with fuels and combustion, heating elements, piping design, heat transfer and various types of central heating installations cover nearly one-third of the entire text.

Those chapters which deal with the psychrometric chart and processes and physiological considerations are excellent, although directed, perhaps, more to the student than the practising engineer. The part dealing with fuels, combustion and heating systems covers some 50 pages but has only indirect relationship to the book's title. The treatment of the refrigeration cycle and cooling systems is clear and concise and the illustrations and examples are well designed to underline the text.

In the preface the authors state that the book is designed for the use of engineering students, professional engineers and architects. A work on air conditioning can hardly be expected to satisfy entirely such a diverse readership, especially when, at the same time, it tries also to deal with matters only indirectly related to its title. This book, therefore, while of value to the engineering student as a first introduction to American practice in heating and ventilating, is unlikely to meet the needs of the practising professional engineer.

TRADE PUBLICATIONS

Copies of any of the following trade publications are obtainable from the addresses given, though distribution is sometimes restricted.

Diesel Engines. ENGLISH ELECTRIC CO. LTD., Kingsway, London, W.C.2. RK/V and RL Mark II Diesel engines for generating, pumping and similar duties both on land and at sea. The first range is available in the naturally aspirated or exhaust gas turbo pressure-charged form for outputs from 248 to 2,504 b.h.p. The second range is intended for slow speed applications with outputs from 683 to 2,890 b.h.p. Fully illustrated technical details. Reference DE213 and DE 209.

Diesel Railway Engines. DAVEY PAXMAN AND CO. LTD., Standard Iron Works, Colchester. The RPHL series of Diesel engines, four to sixteen cylinders, normally aspirated from 120 to 750 b.h.p. Also the YHXL series, pressure charged from 268 to 1,000 b.h.p. Brochure of dimensions, installation notes, cooling and lubricating system diagrams.

Work-Holding Trays. PRECISION COMPONENTS (BARNET), LIMITED, 13 Byng-road, Barnet, Herts. Interlocking bench assembly and storage trays moulded in resin-impregnated compressed fibre. They can be used in a straight line, a semi-circle, or a combination of both, nested or stacked. Illustrated leaflet.

Gears. W. H. BIRD AND SONS, LTD., Albert-road, Bristol, 2. Reduction gear units of various types, single and double worms and single and triple spur reduction units: their characteristics, lubrication and maintenance. Catalogue No. 54, also obtainable at the London office, 44 Tower-hill, London, E.C.3.

Ball Bearings. NEW DEPARTURE DIVISION, GENERAL MOTORS CORPORATION, Bristol, Connecticut, U.S.A. Precision ball bearings for instrument work from $\frac{1}{8}$ in. bore up to $\frac{1}{2}$ in. Various types. Dimensions, capacities, radial play and shaft machining details. Also table of equivalent sizes of other manufacturers. Brochure.

Fine Milling Equipment. F. E. CALLOW (ENGINEERS), LIMITED, Birchill-road, Kirkby Trading Estate, Liverpool. Batch mixer for dry materials, in capacities from 5 to 40 cwt. Grinder mill specifically designed to use the suction cycle. Multi-cyclone built to ter Linden patents. Illustrated leaflets.

Metal Sections. IMPERIAL CHEMICAL INDUSTRIES, LIMITED, Metals Division, P.O. Box 216, Witton, Birmingham, 6. Section rolled from strip in non-ferrous metals, particularly copper, aluminium, brass and bronze, to establish patterns or to customers' requirements. Illustrated leaflet.

Rock Blasting. ATLAS COPCO (GREAT BRITAIN) LTD., Wembley, Middlesex. Supplements Nos. 4 and 5 to the company's "Manual on Rock Blasting" (1953).

Oil Operated Gearboxes. MODERN WHEEL DRIVE LTD., Lindo Lodge, Chesham, Bucks. Marine epicycle reverse and reverse production oil operated gearboxes. Leaflet.

On the Shelf

By Frank H. Smith

Books published by the *Scientific American* are issued, apparently, in sets of five. It would seem that I missed noticing the first set, but the publishers, Simon and Schuster, 630 Fifth-avenue, New York, 20, take pleasure in advising me of the second set, namely, *The Planet Earth*, *Lives in Science*, *The New Chemistry*, *Plant Life* and *The Universe*, all at the very reasonable price of 1·45 dols. each. The publishers, or the *Scientific American*, at 415 Madison-avenue, New York, 17, I am sure, will be pleased to furnish all particulars of these books and the first five. I must say that at rather less than 12*s*. these seem a good "buy"—but it will be impossible to get them in time for Christmas unless someone has a stock of them over here.

In the Unesco *Bulletin for Libraries* for October, F. C. Francis of the British Museum, talks of the reprinting of the Museum catalogue ("Meeting the Challenge"). This Unesco publication, as I may have remarked before, can be obtained through H.M. Stationery Office.

Number 2 of *LLU News*, a news-sheet of the Department of Scientific and Industrial Research Lending Library Unit, 20 Chester-terrace, London, N.W.1 (telephone: HUNter 8361) gives a progress report on the build-up of the Russian literature. At the moment, of course, a lot of people and organisations are going "all out" over Soviet material and probably there will be much duplication of effort. One commercial publisher at least is making a brave effort and is, I believe, trying to channel his efforts to the greatest possible common good, but I wonder if enough co-operation is going on to conserve effort and public expense. I should imagine that there is a limited number of competent translators and with more than one body trying to get in touch with them, they would be aware of any duplication. A Society of Russian Translators, however, could do much to avoid duplication. Anyway, the D.S.I.R. is probably the most accessible source of information on this Russian business and it is evident that they are prepared to help and co-operate up to the hilt.

Newton Photographic Services Limited, 3 Emperor's Gate, London, S.W.7, announce a change of trading policy. The filmstrip, slide, etc., service which they have operated hitherto is discontinued as from December 1 and henceforth they propose to concentrate all their resources on Ektachrome enlargements. If I were to admit that I do not know what an Ektachrome is (I *do* know what an enlargement is) I should show my ignorance. So I won't.

The British Interplanetary Society, while reminding me that my subscription to their *Journal* is due, send me a sheaf of other papers. One slip tells me that eight numbers per annum instead of six, plus rising costs, have pushed the subscription up to 35*s*. per annum. That, apparently, covers all publications which include the *Journal* and their comparatively new *Spaceflight*. The Society also offer an excellent advisory service and buying facility for foreign books and periodicals. The *Astronautics News Bulletin No.* 5 is another sheet, offering all sorts of books on space flight, rocket technology, the upper atmosphere, as well as "package" selections for beginners and the impecunious. This prompts the question, is spaceflight a correct term? Most definitions of "flight" assume the presence of air. What are the etymologists going to do about things chasing around in orbits? For that matter, what *is* the science concerned with intercontinental ballistic missiles?

From the Association Internationale de Cybernetique, 13 rue Basse Marcelle, Namur, Belgium, I hear that they have come to an agreement with Gauthier-Villars, Paris, to publish the *Transactions* of the First International Congress for Cybernetics, which was held from June 26 to 29, 1956. If you happen to have been a delegate, you can get them from the Association, provided that you order before the end of the year, for 600 Belgian francs—15 per cent. lower than publication price. In this case the application must be made to the Association and not to Gauthier-Villars.

I suppose it is easier for a publisher to mail a whole bundle of publicity matter to all the people on his mailing list rather than use a little discrimination and send only those in which a customer is likely to be interested. That is probably why the latest bundle of Interscience Publishers Incorporated, New York and London, contains such lovely items as *Swine Feeding and Nutrition* and *Cosmetics Science and Technology*. The chapter headings in the latter are quite fascinating and "Permanent Waving" is followed by "Hair Straighteners."

Librarianship techniques are building up quite a literature of their own. There have always been papers and books published by the various librarian associations and societies but now that commercial publishers have entered the field one may safely say that librarianship has arrived. Interscience Publishers announce *Documentation and Information Retrieval*, by J. W. Perry and Allen Kent, and *Machine Literature Searching*, by J. W. Perry, Allen Kent and M. M. Berry. We will ignore the fact that the message of the second book will probably tend to put librarians out of work. Interscience Publishers certainly do spread their net in so far as publishing is concerned. Pigs, cosmetics, information retrieval; I wonder what the association of ideas is?

As a result of my little paragraph of November 8 on Edward Stanford Limited, 12-14 Long Acre, London, W.C.2, I have received some more information. It seems that the *Bulletin* which I mentioned is revised every year and this surprises me because I should have thought that a more frequent issue would be justified. Stanfords feel that good maps are more essential to engineers now than ever they were and they offer a speedy service of large-scale versions to anyone interested.

The Aircraft Industries Association of America (equivalent, I suppose, to our Society of British Aircraft Constructors) put out a rather puny but meaty "leaflet-cum-bulletin" each month called *Planes*. They have, however, produced a most useful index covering the period January, 1952, to June, 1957. The Americans rarely seem to index their commercial journals and, when they do, it is only right that due credit should be given.

Design

PHYSICS IN REACTOR DESIGN

A Pictorial Summary of Elementary Nuclear Concepts

Continued from page 759

The third and fourth sections of Mr. G. W. K. Ford's article on reactor physics treat in greater detail the problems of criticality and the slowing-down of neutrons. Both sections are published below. Improved methods of calculating critical size; the reflected reactor and group theories; and breeding will provide the subjects of three further sections to be published next week. The first section, which appeared on page 723 in our issue of December 6, introduced the series and outlined the relevant basic elements of nuclear physics; the second, published on December 13 (page 756), was devoted to essentials of reactor physics. Mr. Ford is Research Manager of the experimental criticality group at the United Kingdom Atomic Energy Authority's establishment at Dounreay in the North of Scotland.

By G. W. K. Ford, M.B.E., M.A., A.M.I.MECH.E., A.M.I.E.E.

(C) CRITICAL SIZES OF PRACTICAL REACTORS

(1) A Physical Picture of Critical Size (*Fig.* 25).—It has been shown, by means of an analytical approach, how the properties of neutron-nucleus scattering, absorption and fission phenomena combine to result in a critical size for a chain reaction. It is now of interest to have a more direct, physical view of what is going on in a just-critical reactor in terms of the distances which the neutrons migrate, and to examine a finite system rather than an infinite slab. It is therefore instructive to examine the very rough approximation shown in Fig. 25. Here it is assumed that the flux distribution in a sphere is linear instead of being of the form $\frac{\sin \pi r/r_0}{r}$, as is correct, and the system is assumed mono-kinetic (v constant) in so far as the cross-sections are assumed constant. The very crude assumption is then made that all the neutrons born outside the dotted circle escape from the system, and that all those born inside are absorbed within the sphere of material. On general grounds one would expect the thickness of the outer shell to be of the order of a diffusion length or so, and knowing in advance the correct answer, it turns out that this thickness should be between L and $\sqrt{3}$ L, depending upon the value of k_∞, which latter must lie between 1 and 3 (on account of the divergency condition on the one hand and maximum possible η values on the other).

Considering the system, it is evident that: (number of neutrons born within the sphere radius R) − (number of neutrons absorbed within the sphere radius R) = (number of neutrons leaking out of the system).

For a given flux distribution in the sphere, the flux gradient, or neutron concentration gradient, at the sphere boundary will be fixed, and therefore the number of neutrons leaking across the boundary will be constant. Therefore, if k_∞, that is, the number of neutrons born for each one absorbed, is large, then l must be made smaller to keep the leakage constant; hence the value of l chosen, $\sqrt{\frac{3}{k_\infty}}$ L.

If now the above equation (in words) is divided by (number absorbed within the sphere radius R) on both sides, the results in Fig. 25 follow. In that figure, the mean ϕ values used follow directly from the similar-triangles relationship shown in the bottom left-hand corner.

It will be seen how the reasoning given results in an equation for the critical condition of exactly the same form as that obtained previously by analysis, and because of the special choice of the value of l the equation is numerically almost correct, despite the crude mathematical model. It is of interest to study the last formula in Fig. 25 for R, the critical radius. Since λ_a and λ_s depend upon the number of atoms per unit volume, it is seen that R varies inversely as N, that is, as the density of the material constituting the fissile mixture. It also depends upon the effective scattering and absorption cross-sections of the mixture, large values of which make R small; but the absorption cross-sections contributing to σ_a affect R in a more complicated manner in that they dominate the all-important value of $(k_\infty - 1)$, since they control the values of f and η.

(2) Range of Practicable Reactors (*Fig.* 26).—In a thermal reactor the neutrons migrate between birth and death a greater crow-flight distance than that characterised by the diffusion length L_d on account of the slowing-down process, the characteristic length of which is L_s.

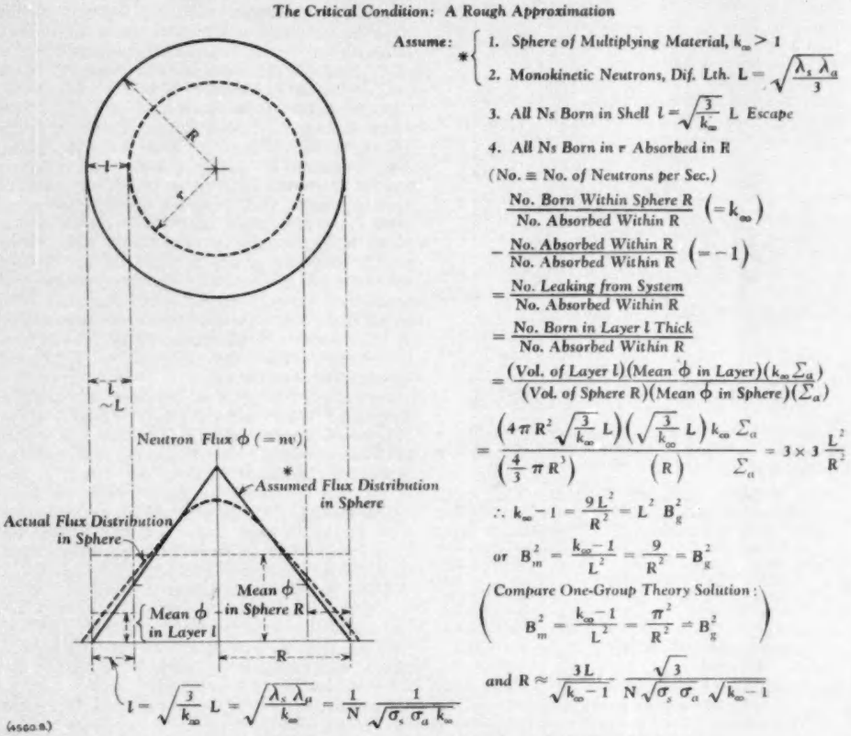

The Critical Condition: A Rough Approximation
Assume:
1. Sphere of Multiplying Material, $k_\infty > 1$
2. Monokinetic Neutrons, Dif. Lth. $L = \sqrt{\frac{\lambda_s \lambda_a}{3}}$
3. All Ns Born in Shell $l = \sqrt{\frac{3}{k_\infty}}$ L Escape
4. All Ns Born in r Absorbed in R
(No. ≡ No. of Neutrons per Sec.)
$\frac{\text{No. Born Within Sphere R}}{\text{No. Absorbed Within R}} \left(= k_\infty\right)$
$- \frac{\text{No. Absorbed Within R}}{\text{No. Absorbed Within R}} \left(= -1\right)$
$= \frac{\text{No. Leaking from System}}{\text{No. Absorbed Within R}}$
$= \frac{\text{No. Born in Layer l Thick}}{\text{No. Absorbed Within R}}$
$= \frac{(\text{Vol. of Layer l})(\text{Mean } \phi \text{ in Layer})(k_\infty \Sigma_a)}{(\text{Vol. of Sphere R})(\text{Mean } \phi \text{ in Sphere})(\Sigma_a)}$
$= \frac{\left(4\pi R^2 \sqrt{\frac{3}{k_\infty}} L\right)\left(\sqrt{\frac{3}{k_\infty}} L\right) k_\infty \Sigma_a}{\left(\frac{4}{3}\pi R^3\right) \quad \left(R\right) \quad \Sigma_a} = 3 \times 3 \frac{L^2}{R^2}$
$\therefore k_\infty - 1 = \frac{9L^2}{R^2} = L^2 B_g^2$
or $B_m^2 = \frac{k_\infty - 1}{L^2} = \frac{9}{R^2} = B_g^2$
(Compare One-Group Theory Solution: $B_m^2 = \frac{k_\infty - 1}{L^2} = \frac{\pi^2}{R^2} = B_g^2$)
and $R \approx \frac{3L}{\sqrt{k_\infty - 1}} \quad \frac{\sqrt{3}}{N\sqrt{\sigma_s \sigma_a}\sqrt{k_\infty - 1}}$
R
l
~L
Neutron Flux ϕ (= nv)
Assumed Flux Distribution in Sphere
Actual Flux Distribution in Sphere
Mean ϕ in Sphere R
Mean ϕ in Layer l
R
$l = \sqrt{\frac{3}{k_\infty}} L = \sqrt{\frac{\lambda_s \lambda_a}{k_\infty}} = \frac{1}{N} \frac{1}{\sqrt{\sigma_s \sigma_a k_\infty}}$
(4500 8)

Fig. 25 A physical picture of critical size.

(The suffix d is used in this section and elsewhere later in the article to distinguish clearly the diffusion length L_d from the slowing-down length L_s.) To a first approximation the combined characteristic length, M (where $M^2 = L_s^2 + L_d^2$), may be used to replace L (the diffusion length in the monokinetic reactor) in the formula arising from Fig. 25. This substitution is examined in more detail in section D(2) and Fig. 28 below, but in the meantime it is of interest to use this concept to examine how the actual magnitudes of L_d and L_s which occur with the materials of practical interest, affect the critical sizes encountered in practice.

In Fig. 26 the "correct" one-group formula for the critical radii of bare spheres has been plotted in terms of R and M for various values of k_∞. Along the top of the diagram the separate values of L_s (slowing down length) and L_d (diffusion length) have been indicated. It should be realised that the L_d given is for pure moderator, and that this value is considerably affected by the presence of fuel: the better the moderator, the greater the effect. Approximately, $L_s^2 = L_d^2 (1 - f)$, where L_s is the effective diffusion length in the reactor and f is the fuel utilisation factor. Thus, the slowing-down length L_s in heavy water is so short in comparison to the diffusion length, L_d, that M_0, the migration length in pure moderator, is almost equal to the diffusion length. But in actual heavy-water reactors, M is considerably shorter than M_0 on account of the effect of the absorption of neutrons by fuel upon L_d.

Such effects have been indicated in Fig. 26 by the pairs of vertical lines which refer to four important reactor systems. Between the pairs of vertical lines lie the values of M actually encountered in practical designs, for the various systems indicated. Besides the shortening of M_0 in heavy water already referred to, it is noteworthy that in the case of light water the value of M_0 is dominated by L_s, the slowing down length. Since this is not effected by absorption, M does not differ greatly from M_0 and shows little variation over the range of possible reactor types. One would also expect that the M corrected one-group theory would apply well to heavy-water reactors, in which L_d is a good

deal larger than L_s, whereas in light-water systems L_s is dominant and so leakage during slowing-down would be expected to be important. In fast-reactor systems there is very little slowing-down, so that the M-value may be expected to apply fairly accurately, although in this case the system is not large in comparison with the mean free paths, and diffusion theory itself is but a rather crude approximation.

Parallel to the k_∞ lines have been drawn (dotted) η-lines for U235 and plutonium (Pu 239): the value shown for the latter refers to fission by fast neutrons. These are the maximum conceivable values of k_∞ assuming no absorption of neutrons in the structure, coolant or moderator (if present). The shaded regions show the limits of k_∞ values actually encountered in practical systems.

It will be realised from the study of this diagram how the core sizes of reactors of different types come to vary between such wide limits, from the tiny bare sphere of pure U235 metal (" Godiva " in the diagram) to the large graphite systems at the top right-hand side of the diagram.

A reflector makes a considerable saving in the amount of material required to make a given system critical. Because the ratio $\frac{\text{leakage}}{\text{absorption}}$ $\left(\propto \frac{L^2}{R^2}\right)$ is larger for small reactors (k_∞ large), the effect of a reflector is more pronounced with small systems. Thus, a reflector can halve the diameter of a small light-water reactor, whereas in a graphite reactor a reflector will only save a few feet on a radius of 10 to 20 ft. In most cases, the reflector for the reactor would be an outer shell of pure moderator (usually, but not always, the same material as is used for the core moderator) about one or two diffusion lengths in thickness. For a fast reactor in which it was not desired to " degrade," or slow-down, the leakage neutrons, the reflector would be a heavy fissile-fertile-scattering material such as uranium (in which fast fission and Pu production would take place) or a heavy, inert scattering-only material such as bismuth, if fission and breeding within the reflector were not required.

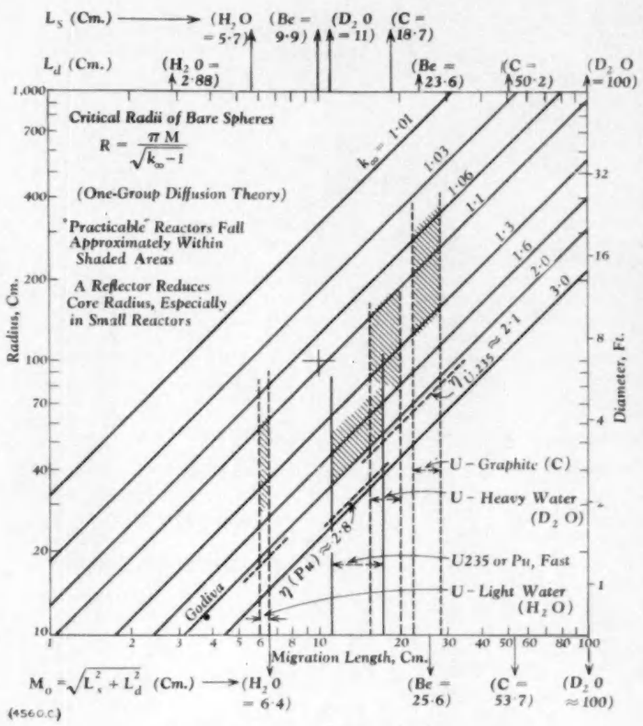


Fig. 26 Range of sizes of practicable reactors.

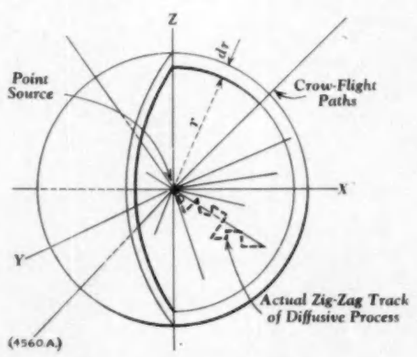


Fig. 27 Averaging of crow-flight tracks.

(D) THE SLOWING-DOWN PROBLEM

(1) Point Source (*Fig.* 27).—Because it simplified the demonstration of the mathematics, the neutron diffusion considerations in this article so far have been dealt with in the main in one dimension: or, more accurately, the mathematical models have been so chosen that they resulted in two-variable equations, and the only geometric axis along which averaged variations have taken place has been the OX-axis. When considering the fate of a single neutron, however, or a stream of neutrons being emitted isotropically by a point source, as compared to the collimated beams and plane sources used so far, it is necessary to consider three-dimensional spreading of the neutrons. It is not intended to probe this matter deeply, but to assist the further argument it is desirable to recognise that the average distance to which a neutron will penetrate during its migration away from a point source in an " infinite " medium, during a diffusive process, is two or three times larger than the characteristic length (for example, L) as calculated for infinite plane source conditions, depending upon how the average is reckoned. It is usual to compute the mean-square characteristic distance in the case of diffusive processes since this quantity has the special mathematical convenience that successive mean-square characteristic distances can be simply added together to give a resultant mean-square distance, as will now be seen.

Consider a single diffusive process, such as the slowing-down of a neutron as represented by the track AB in Fig. 28. At the termination of this process, at B, the next process commences. Since we are dealing with random processes and have been assuming isotropic scattering at each event, the first free path in the new process, BB′, is equally likely to take place in any direction, and the resultant complete crow-flight track of the diffusive process B C is also equally likely to lie in any direction (that is within the solid angle 4π) as viewed from B. Considering the average track for the first process, A B, followed by the average track for the second process, B C, the track B C could have been directed along a line at any angle between 0 and 180 deg. with respect to A B (that is, $\angle$ A B C between 0 and 180 deg.); and B C could lie in any plane containing A B. Therefore, the average second track will be directed at 180/2 deg. = 90 deg. to the direction of the first, and the length of the resultant crow-flight track for both processes is of the magnitude given by Pythagoras' theorem applied to the right-angled triangle A B C, that is, $A C^2 = A B^2 + B C^2$. Hence, if mean-square tracks are used they may be directly added to produce the resultant. It will have been observed that it is squares of the characteristic lengths for diffusion processes which always appear in the differential equations because of the relationship between the diffusion constant, the absorption cross-sections and the characteristic lengths. Notice that the square roots of mean-square distances are not, in general, quite the same as the arithmetical average distances, but they are generally closely similar.

The magnitudes of the mean-square characteristic lengths for the point source can be calculated quite simply by applying the methods shown in Figs. 18 and 20 to the geometry shown in Fig. 27, from which it will be found that $\overline{r^2} = 6\,L^2$, so that the root-mean-square distance travelled by a single neutron emitted at a point in an infinite diffusive medium is $\sqrt{6}\,L$, or about $2\frac{1}{2}$ times the characteristic length. Thus, if there is a succession of two diffusive processes, as in Fig. 29, the total root-mean-square distance migrated from the point of emission is $l_m = \sqrt{6}\,M$, where M is known as the migration length, and $M^2 = L_s^2 + L_d^2$, in which L_s is the slowing-down length, and L_d is the diffusion length, L, the suffix d having been added for clarity in the present discussion.

(2) Migration Length Correction (*Fig.* 28).—It will be seen from Fig. 28 that the slowing-down distance depends upon the average number of collisions during slowing-down, C_s, and the average distance travelled between collisions, λ_s. The first factor (number of collisions) depends upon the relative masses of the neutron and the moderator nucleus, the second (scattering mean free path) depends upon the values of σ_s and N. It is thus a quantity somewhat different in nature from the diffusion length and cannot be worked into a diffusion equation directly. However, the significance of the diffusion length in reactor theory is its effect upon neutron leakage (it does not directly affect k_∞), and the slowing-down distance may also be expected to affect neutron leakage, as indeed it does. An approximate way in which to utilise the slowing-down length is to derive the critical size using thermal neutron diffusion theory and then to substitute M^2 instead of L_d^2 in the result to account for the larger distances travelled from the point of neutron birth on account of slowing-down. This is an inexact correction, but gives quite useful results.

The effect of the substitution can be seen from the derivation of the diffusion equation: it has the effect of altering the apparent size of λ_s and/or λ_a. Supposing that the effect has been to modify λ_s, that is, " λ_s " becomes larger (" σ_s" becomes smaller) to account for the greater distance travelled by the neutron before absorption, but it is assumed that λ_a (and therefore σ_a and Σ_a) has remained fixed. This modification in itself would be satisfactory: but the errors arise because such a modification assumes that the absorption process is equally likely to occur at any portion of the neutron's total track, whereas in fact this process does not begin to occur (to any significant extent—see Fig. 6) until the neutrons have been thermalised. Therefore the fates of neutrons born near the boundary of the reactor will not be correctly accounted for in the diffusion equation because

Continuing Design

many of them will actually escape from the system during slowing-down and will never be given the chance to be captured, which the M-modified diffusion equation implies they have had. More neutrons will escape than we expect, therefore, and so it may be anticipated that this approximation will yield critical sizes which are too small: the actual reactor must therefore be made slightly bigger to catch some of the neutrons which would otherwise escape during slowing-down, if it is to be critical.

It would also be expected that the relative magnitude of L_s and L_d would affect the accuracy of this approximation, so that if the slowing-down length is short by comparison with the diffusion length the result might be expected to be more accurate than if the other way about.

(3) Resonance Escape Probability (*Figs.* 29 *and* 30). So far only homogeneous systems have been discussed specifically, although most of the general arguments given so far apply to heterogeneous reactors as well. Specific points of difference relate to the fuel utilisation factor, f, and the fast fission factor, ϵ. Also, pure fissile material mixed with pure moderator has been assumed, whereas an important class of reactors uses natural or near-natural uranium as fuel, and the absorption of neutrons by resonance phenomena must be accounted for.

In order to achieve a value of k_∞ greater than unity using natural uranium it is necessary to moderate the neutrons to thermal energy and to mix the moderator and fuel with the latter in the form of "lumps," usually rods for engineering convenience. This is because for every part of highly fissile U235 in the natural metal there are about 140 parts of U238, which acts as a powerful absorber of any neutrons with energies that happen to lie in the range between about 7 eV and 200 eV (see Figs. 6 and 31). In order to avoid this serious competition with the desired fission-promoting capture it is necessary to arrange for as many neutrons as possible, following their birth within a lump and their initial escape at high energy, to undergo all, or nearly all, their slowing-down collisions in pure moderator so that very few will re-enter uranium lumps while in the resonance energy range. This effect is progressively improved (that is p in Fig. 29 moves nearer to unity) as the lump or rod diameter increases, since for a given uranium-to-moderator ratio the distances between rods increases and the chances of a neutron re-entering a rod during the slowing-down process are reduced. With this improvement there is also a slight increase in neutron production due to fast fission (ϵ factor), but a limit is set to the profit to be obtained from lumping by the deterioration of f.

The effects of lumping upon f, the fuel utilisation factor (usually called the thermal utilisation factor in thermal reactors), may be seen in qualitative terms from the bottom left-hand corner of Fig. 30. The effect of a lump of a strong absorber is to cause a local depression of the neutron flux density. This means that the flux in the non-fuel parts of the reactor is disproportionately high so that the wastage of neutrons by parasitic absorption in the moderator is also increased correspondingly: hence the reduction of f.

(4) The Fast Fission Factor

The fast fission factor ϵ is only important in natural-uranium reactors (in thermal systems, that is) because in natural-uranium thermal reactors it is necessary to accept the 140 atoms of U238 co-existing with each thermal-neutron-fissile U235 atom. This results in a considerable amount of uranium metal to contain a small amount of the U235 isotope, and therefore newly-born fission (fast) neutrons escaping from the rod have a slight chance of a fission-producing collision (despite the small cross-section of about 0·5 barn for the process) occurring as the neutron leaves the rod. This can contribute anything between about 2 per cent. and 6 per cent. to the total fission-neutron production, that is $\epsilon \simeq 1{\cdot}02$ to $1{\cdot}06$, which is a substantial effect and must be taken into account when calculating k_∞ for a heterogeneous reactor using natural or near-natural uranium. This factor is unity for homogeneous reactors and almost so for highly enriched heterogeneous reactors, in which the fuel-plates have to be very thin or the U235 dispersed in an inert diluent material such as aluminium. The heterogeneity in such reactors is arranged for engineering convenience (for example cooling), not, of course, for resonance escape reasons since there is little U238 present.

(5) The "Four-Factor" Formula (*Fig.* 29).— The combined effects of p and ϵ upon k_∞ are illustrated in Fig. 29, which includes as before the effects of η and f; the latter factor, f, will have been altered from the definition given in section B(1) 14 if the fuel has been lumped. The resultant formula for the infinite multiplication constant, $k_\infty = \eta\,\epsilon\,f\,p$, is the well-known "four-factor" formula. If it has not been lumped, f will be as before and ϵ will be unity.

It is necessary to consider the local effects of lumping fuel, as discussed above, in order to calculate the factors ϵ, p and f in heterogeneous reactors, but having obtained them, and hence k_∞, the critical size and average flux distribution of the whole reactor is calculated by treating it as a homogeneous system, as already discussed, using this k_∞ value.

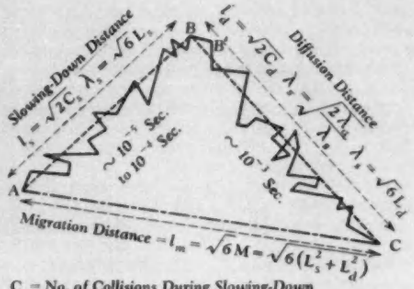
(6) Resonance Escape Probability for Homogeneous Mixture (*Fig.* 31).— In the simple case of a homogeneous mixture of uranium and moderator, it is of interest to examine the form of the resonance escape probability in some detail as has been done in Fig. 31, which attempts to illustrate graphically the factors affecting the value of p. The figure shows at the top a graph of the continuous slowing down "model" of the real collision-by-collision slowing-down process. Below it is a representation of the absorption process, which mainly occurs at the rather steep steps X to Y due to the spacing of the resonances, but which is represented in order to clarify the diagram by the continuous sloping line XY. At any one collision, a neutron has a chance of scattering rather than of being absorbed of $\left(\frac{\Sigma_s}{\Sigma_s+\Sigma_a}\right)$. In two such collisions, the chance is $\left(\frac{\Sigma_s}{\Sigma_s+\Sigma_a}\right)^2$; in C collisions it is $\left(\frac{\Sigma_s}{\Sigma_s+\Sigma_a}\right)^C$. The quantity ξ is the average logarithmic energy loss per collision and is easily calculated from the mass of the neutron and the mass of the target nucleus: it is derived in each of the first six text-books referred to in the references to be given at the end of the article. Hence, the number of collisions in an elemental interval of log E, namely $d(\log E)$, is simply $\frac{d(\log E)}{\xi} = \frac{dE}{\xi E}$. Hence if n neutrons enter the elemental energy range $d(\log E)$ the number n' which escape being absorbed in the range is $n' = n\Delta p_E$, where Δp_E is the elemental probability of escape as indicated in Fig. 31.

Recalling the two infinite series:

$$e^{-mx} = 1 - mx + \frac{m^2x^2}{2} - \ldots$$

and $$(1-x)^m = 1 - mx + m(m-1)\frac{x^2}{2} - \ldots$$

the reasoning in the right-hand bottom corner of Fig. 31 then leads directly to the expression for p, in which the exponent of e is $-\left(\frac{N_u}{\xi\,\Sigma_s}\right) \times$ (Effective Resonance Integral). The effective resonance integral is a quantity which must be measured by experiment as an integral quantity, for the detailed cross-section data and the detailed effects of the resonances upon the 1/E flux spectrum, which depends upon the uranium concentration in the mixture. are not known to a



C_s = No. of Collisions During Slowing-Down

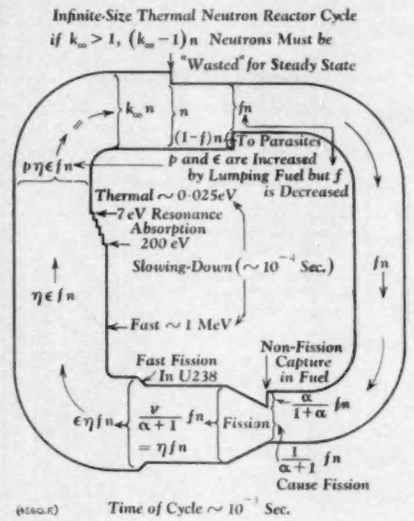
$$= \frac{\log(\text{Source Energy}) - \log(\text{Thermal Energy})}{\text{Average (log Energy Loss per Collision)}} = \frac{\log\left(\frac{E_s}{E_t}\right)}{\overline{\log}\left(\frac{E_b}{E_a}\right)}$$

C_d = No. of Collisions During Thermal Diffusion

$$= \frac{\text{Average Total Zig-Zag Travel Before Absorption}}{\text{Scattering Mean Free Path}} = \frac{\lambda_a}{\lambda_s}$$

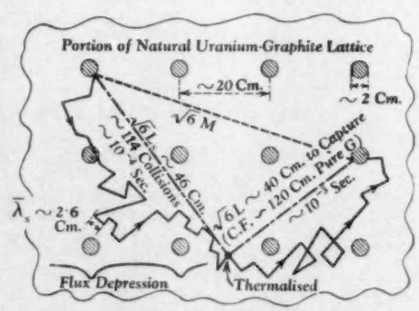
(4560.C)

Fig. 28 Neutron migration in infinite medium.



(4560.F)

Fig. 29 The "four-factor" formula.



Experimental Eff. Res. Integral for Lumped Fuel

$$\int_{E_{th}}^{E_f} (\sigma_a)_{eff} \frac{dE}{E} = \int (\sigma_a)_{eff}\, d(\ln E)$$

$$= 9{\cdot}25\left(1 + 2{\cdot}67\,\frac{S}{M}\right) \text{Barns}$$

$$\frac{S}{M} = \frac{\text{Surface Area in Sq. Cm.}}{\text{Mass in Grams}} \quad \text{for Uranium Rods}$$

(4560.G)

Fig. 30 Lumping of fuel.

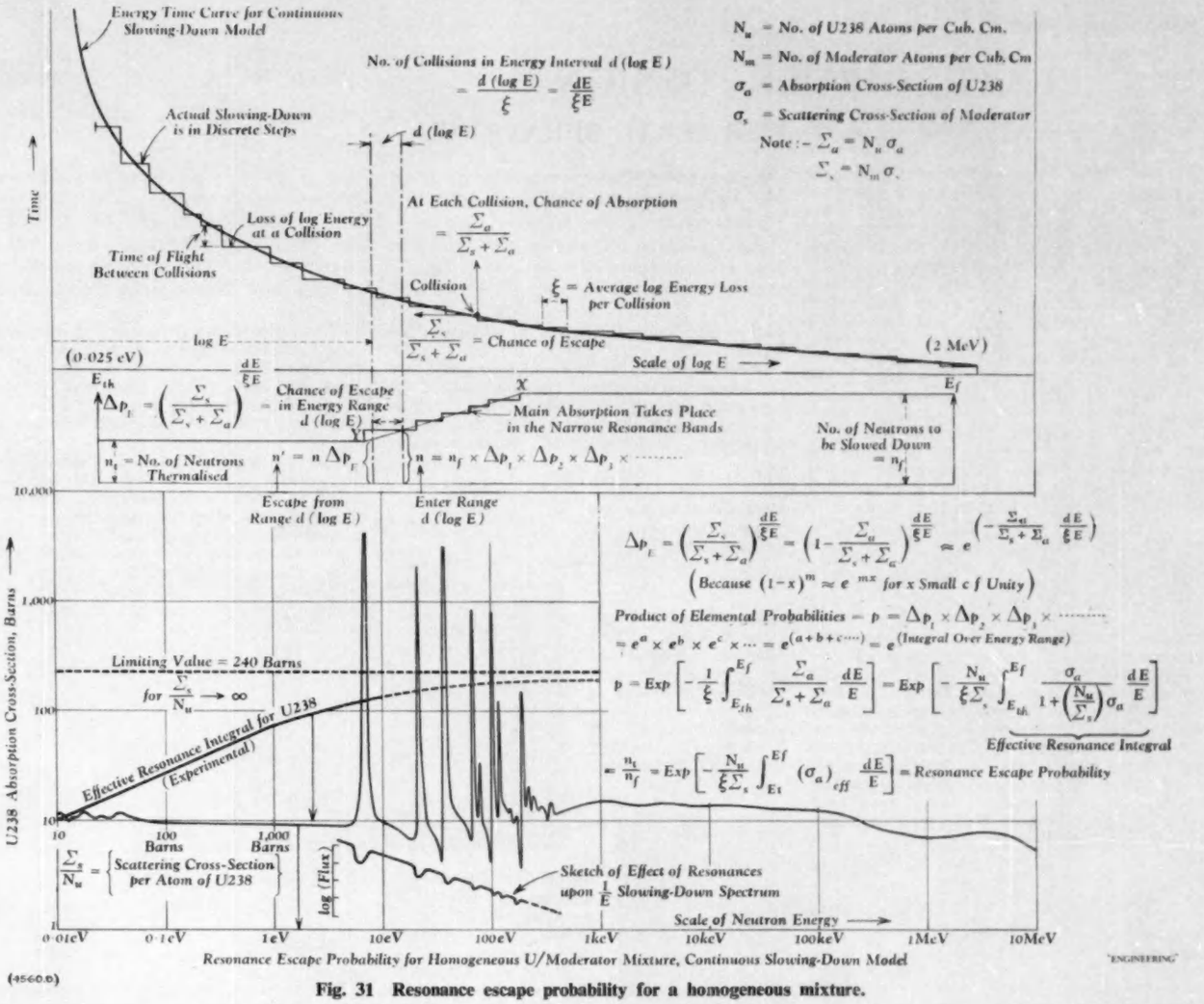

Energy Time Curve for Continuous Slowing-Down Model
No. of Collisions in Energy Interval d (log E) = d (log E)/ξ = dE/ξE
Actual Slowing-Down is in Discrete Steps
d (log E)
Time
Loss of log Energy at a Collision
Time of Flight Between Collisions
At Each Collision, Chance of Absorption = Σa/(Σs + Σa)
Collision
ξ = Average log Energy Loss per Collision
Σs/(Σs + Σa) = Chance of Escape
log E
(0·025 eV)
(2 MeV)
Scale of log E
Eth
Ef
Δp = (Σs/(Σs + Σa))^(dE/ξE)
Chance of Escape in Energy Range d (log E)
Main Absorption Takes Place in the Narrow Resonance Bands
No. of Neutrons to be Slowed Down = nf
nt = No. of Neutrons Thermalised
n' = n Δp
n = nf × Δp1 × Δp2 × Δp3 × .....
Escape from Range d (log E)
Enter Range d (log E)
U238 Absorption Cross-Section, Barns
10,000
1,000
100
10
1
Limiting Value = 240 Barns
for Σs/Nu → ∞
Effective Resonance Integral for U238 (Experimental)
10
100 Barns
1,000 Barns
Σs/Nu = {Scattering Cross-Section per Atom of U238}
log (Flux)
Sketch of Effect of Resonances upon 1/E Slowing-Down Spectrum
Scale of Neutron Energy
0·01eV
0·1eV
1eV
10eV
100eV
1keV
10keV
100keV
1MeV
10MeV
Resonance Escape Probability for Homogeneous U/Moderator Mixture, Continuous Slowing-Down Model
(4560.D)
"ENGINEERING"
Nu = No. of U238 Atoms per Cub. Cm.
Nm = No. of Moderator Atoms per Cub. Cm
σa = Absorption Cross-Section of U238
σs = Scattering Cross-Section of Moderator
Note :- Σa = Nu σa
Σs = Nm σs
Δp = (Σs/(Σs + Σa))^(dE/ξE) = (1 − Σa/(Σs + Σa))^(dE/ξE) ≈ e^(−(Σa/(Σs + Σa))(dE/ξE))
(Because (1−x)^m ≈ e^(mx) for x Small c f Unity)
Product of Elemental Probabilities = p = Δp1 × Δp2 × Δp3 × .....
= e^a × e^b × e^c × ... = e^(a+b+c....) = e^(Integral Over Energy Range)
p = Exp [−(1/ξ) ∫ from Eth to Ef (Σa/(Σs + Σa)) (dE/E)] = Exp [−(Nu/ξΣs) ∫ from Eth to Ef (σa/(1 + (Nu/Σs)σa)) (dE/E)]
Effective Resonance Integral
= nt/nf = Exp [−(Nu/ξΣs) ∫ from Et to Ef (σa)eff (dE/E)] = Resonance Escape Probability

Fig. 31 Resonance escape probability for a homogeneous mixture.

sufficient degree of accuracy to enable a graphical integration to be made. But the effective resonance integral depends only upon σ_a and $\frac{N_u}{\Sigma_s}$; the former, σ_a, depends only upon the resonance absorber (U238 in this case), and $\frac{N_u}{\Sigma_s}$ is a measure of the scattering cross-section (of moderator nuclei) associated with each resonance absorber (U238) atom: it does not depend upon the properties of the particular moderator to be used. Therefore the experimental curve given in the lower left-hand side of Fig. 31 can be obtained, from which it is now possible to calculate p for any chosen moderating substance (which effects ξ) and value of the ratio $\frac{N_u}{\Sigma_s}$. For the heterogeneous case, again experimental measurement is necessary, and for uranium the empirical formula given in Fig. 30 (bottom) has been obtained. It is seen here how the effective resonance integral depends upon the surface-to-volume ratio of the uranium rods.

ITALIAN NUCLEAR RESEARCH

At the end of 1956 Italy had some 200 graduates working on nuclear power problems. For a country that expects to meet part of its electricity needs from nuclear power stations by 1965 this is not an impressive number. Italian nuclear research is spread over three institutions. Private industry has a share in only one of these. This is C.I.S.E. (Centro Informazioni Studi Esperienze) set up in 1946. Maintained jointly by the State and private industry, it is essentially a development organisation concerned with industrial applications of nuclear energy. Among its achievements are the construction of a pilot plant for producing metallic uranium and the preparation of plans for a heavy-water plant. It has a total staff of about 90.

The principal State organisation C.N.R.N. (Comitato Nazionale Richerche Nucleari) was set up in 1952 as an offshoot of the National Research Council to co-ordinate nuclear work, and arrange collaboration with international and foreign organisations. C.N.R.N. comes under the orders of the Ministry of Industry and Commerce. It works through ten technical commissions which specialise on such topics as training of staff, economic problems, materials for reactors, industrial uses, protection against radiation, uses of isotopes, and medicine. For fundamental research C.N.R.N. has its subsidiary, the I.N.F.N. (Instituto Nazionale di Fisica Nucleare) divided between the universities of Turin, Milan, Padua and Rome. An accelerator is being built at the Institute's laboratory at Frascati. Prospecting for radioactive minerals in Italy is another of its responsibilities. Both C.I.S.E. and C.N.R.N. are concerned at the shortage of nuclear technicians. Plans for training graduate specialists envisage stepping up the present annual intake of about 70 to 180 by 1959 and 360 by 1961. Apart from training its scientists at home, C.N.R.N. sends promising students to Harwell and the United States.

ADVISERS FOR ITALY

British and American advisers are now in Italy to select a site for the construction of a nuclear power station in the lower Garigliano valley in the southern part of the country. They are members of the international advisory panel appointed by the World Bank. The British representatives are Dr. J. M. Hill, of the United Kingdom Atomic Energy Authority's Industrial Group at Risley, and Mr. R. E. Newell, managing director of I.C.I.'s Wilton Works. The station will have an initial installed capacity of 150 MW.

AND FOR TURKEY

An Argonne National Laboratory chemical engineer has visited Turkey to advise the Turkish government on its nuclear reactor planning. He is Mr. Leonard E. Link, associate chemical engineer in the reactor engineering division at Argonne. The Turkish Government had requested assistance from the United States Atomic Energy Commission. Mr. Link has been asked to advise on specifications and site selection for a research reactor that it hopes to build soon. He is the author of an economic study of Argonne's Experimental Boiling Water Reactor.

Continuing **Design**

PLATE GIRDER DESIGN

FLANGE STIFFNESS AND WEB PLATE BEHAVIOUR

By K. C. Rockey, M.SC.(ENG.), PH.D., A.M.I.C.E., A.M.I.MECH.E.*

An examination of the post-buckled behaviour of web plates subjected to shear has shown that the buckle formation, and more particularly the depth of the buckles, is affected by the flexural rigidity of the flanges. Very large lateral deflections of the web plate occur if the flange rigidity is less than a given minimum value, the magnitude of which varies with the ratio of the applied load to the buckling load of the web plate. As a result of the investigation, it is clear that many girders being designed at present have flanges which are too flexible.

The buckling of a plate subjected to shear does not result in immediate failure of the panel, but merely produces a change in the manner in which any additional shear load is carried by the plate. After buckling has occurred, the rigidity of the plate normal to the principal compressive stresses is reduced, with the result that any additional shear force is not carried by a pure shear action where the principal tensile and compressive stresses are equal, but is carried in part by a pure shear action, and in part by truss action, as illustrated in Fig. 1. Thus, after buckling has occurred, the principal compressive stresses increase slowly, whilst the principal tensile stresses increase rapidly. These principal tensile stresses, which act along length of the waves, exert lateral and direct loads upon the flanges. It is therefore important that the flanges shall have sufficient rigidity to carry these loads.

In recent years, with the increasing use of arc welding, structural elements have become much lighter. This applies in particular to plate girder construction where arc welding permits a simple connection between flange and web plate, as shown in Fig. 2. It will be noted, however, that with this form of construction, the flexural rigidity of the flange about an axis passing through the centroid of the flange and normal to the plane of the web plate is low. Such a flange would, therefore, be incapable of carrying lateral loads without deflecting badly.

The effect of such flange deflections will be to increase the depth of the plate buckles, and this will cause a corresponding increase in the bending stresses which will reduce the ultimate load carrying capacity of the panel.

Such increases in the depth of waves and changes in the wave formation have been observed by the author[1] and others. [2, 3] To date, however, as far as the author is aware, no experimental tests have been conducted to determine the effects of flange flexibility upon the behaviour of the web plates of normal structural plate girders. Aeronautical engineers have conducted tests but the spars tested by them were typical of normal aircraft construction, and were therefore rigid compared with the flanges of structural girders.

The influence of flange rigidity on the behaviour of shear panels operating in the post-buckled range has been examined theoretically by Leggett and Hopkins[4] in this country, and Bergman[5] in Sweden. Leggett and Hopkins' paper dealt with webs operating as tension fields, whilst Bergman showed the effect which unrestricted movement of the flanges had upon the formation of the buckled plate; his results are given in Fig. 3. It is perhaps worth noticing that the value of the maximum deflection which Bergman obtained for the case of flanges kept a fixed distance apart is much lower than that which has been obtained by other theoretical investigators[6, 7] and from experimental investigations.

Unfortunately, the results of these excellent papers cannot be directly applied to the case of practical beams operating in the immediate post-buckled range, that is for values of

$$\frac{W}{W_{cr}} \gtrless 4:1.$$

The work of these authors[4, 5] has, however, shown that the effects of flange flexibility upon the post-buckled behaviour of web plates can be considerable.

The effects of flange flexibility were first observed by the author[1] when testing a model steel girder (TG4). This girder, which was of all welded construction, was one of four girders tested during a preliminary series of experiments before carrying out a study of stiffened web plates.

While testing girder TG4, it was noticed that just above the theoretical buckling load of the web plate, the web had developed buckles which were inclined at approximately 45 deg. to the longitudinal axis of the girder. However, as the load was increased still further, the direction of these buckles was seen to alter, the angle which the buckles made with the longitudinal axis decreasing, until finally, there was one large dominant wave running diagonally from corner to corner of the panel, and of the form shown in Fig. 4.

A brittle lacquer[8] was used to determine the stress distribution in the web plate, and Fig. 5 shows the crack pattern obtained. The cracks which occurred after the panel had buckled lie at right angles to the principal tensile stresses. Since it was not possible to photograph the actual crack patterns, chalk lines have been placed on the panel giving the position and direction of the cracks. It will be noted that the cracks occur only in the region of the deep diagonal wave, large adjacent areas of the web plate being free from cracks, this indicating that these areas were lightly stressed. The girder failed when the shear stress was 7·15 tons per sq. in., this being

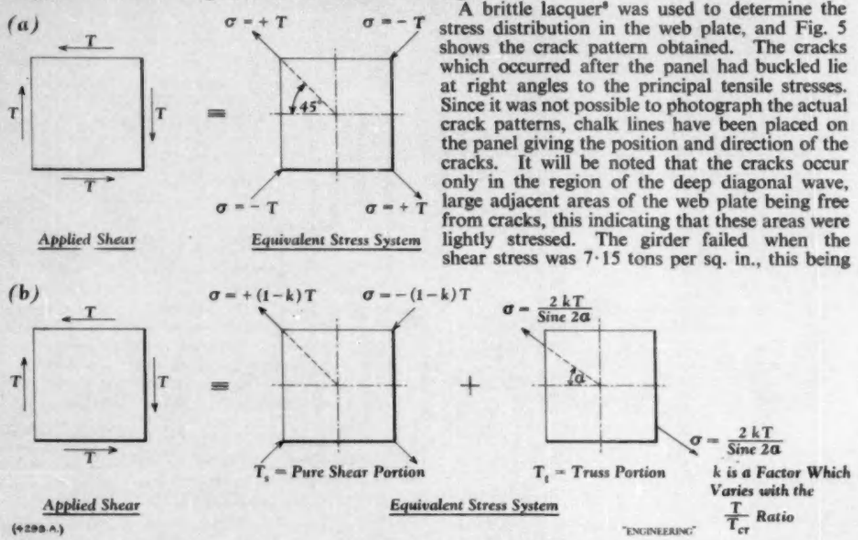


Fig. 1 Stress systems in a web subjected to shear. Fig. 1a shows the condition for a plane web, while Fig. 1b shows it for a buckled web.

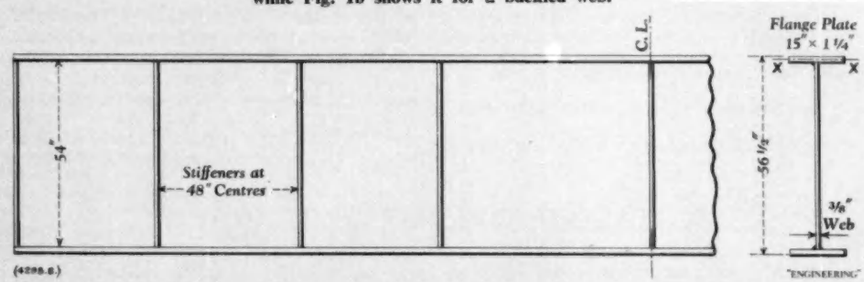


Fig. 2 Typical design for an all-welded plate girder (see Ref. 10), showing the usual flange-web assembly.

SYMBOLS USED

- W = Applied load
- W_{cr} = Critical or buckling load of web plate
- T = Applied shear stress
- T_{cr} = Critical shear stress
- σ = Principal stress
- k = A diagonal tension field factor—which varies with ratio $\frac{W}{W_{cr}}$
- b = Width of panel between stiffeners
- d = Depth of panel between flange members
- α = Aspect ratio $\frac{b}{d}$
- t = Thickness of web plate
- t_f = Thickness of attached legs of flange members
- δ = Lateral deflection of web plate
- I = Inertia of flange member about XX-axis (see Fig. 2)

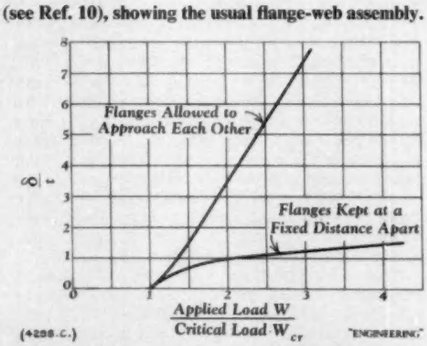


Fig. 3 Bergman's theoretical curves (see Ref. 5) showing influence of flange movement upon the magnitude of the web deflections of a shear panel.

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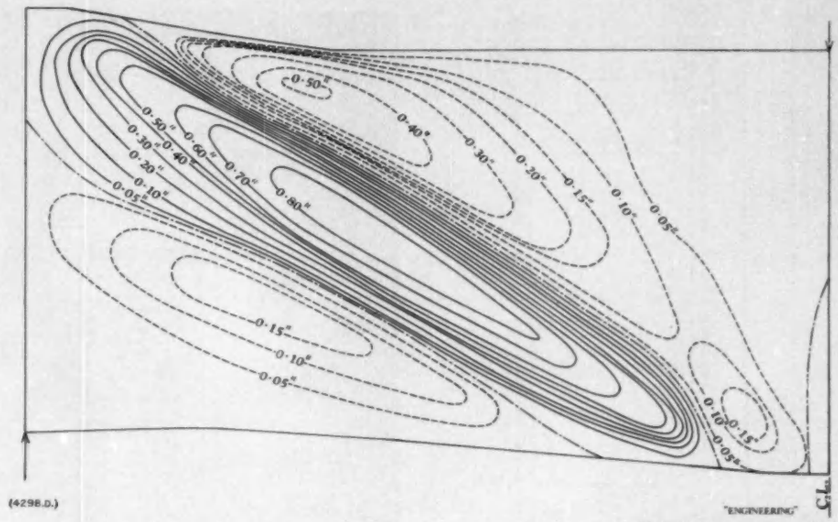


Fig. 4 (above) Residual web deflections after test to failure of girder having a low flange stiffness.

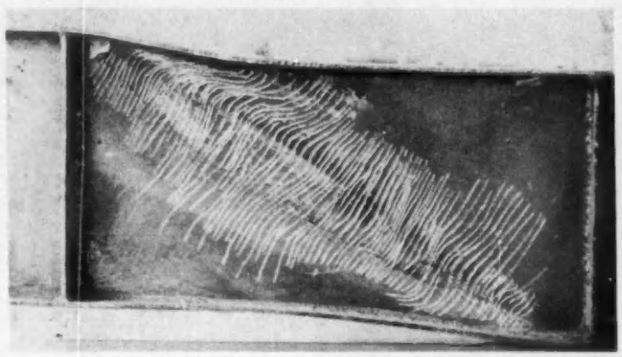


Fig. 5 (left) Stress distribution in web of girder with flanges of low stiffness, as obtained by a brittle lacquer. The crack pattern only covers the highly stressed diagonal strip, the remaining areas of web being lightly stressed.

2·46 times the upper critical shear stress for the panel.

At this stage, only one of the four girders had not been tested. In view of the behaviour of girder TG4, it was decided to stiffen the flanges of this last girder. This was done by bolting pairs of 2½ in. × 2½ in. × $\frac{5}{16}$ in. angles to the flanges. The girder was then tested to destruction and the behaviour of the web plate examined. In this test the waves did not change in direction during the test, although they did change in shape, inasmuch that their wave length decreased and more waves were formed, as shown in Fig. 7, which is a contour plot of the web plate after the girder had been tested to failure and unloaded.

The stress distribution in this case was more uniform, as shown by the crack pattern shown in Fig. 6. The shear stress at failure, which is 1·6 times the stress obtained with girder TG4, was 11·4 tons per sq. in., this being approximately equal to the shear yield stress of the web plate material.

It was clear from these two tests that the flexural rigidity of the flanges had a considerable influence upon the post-buckled behaviour of web plates subjected to shear. As a result it was decided to fully investigate this problem.

APPARATUS AND TEST PANELS

It is clear that two factors can influence the behaviour of the flanges and the web plates, namely, the applied shear and the applied bending moment. In order to determine the relative importance of these two factors, it was decided that in the first series of tests the bending stresses should be small compared with the shearing stresses.

Since it was very desirable that yielding should not occur until the web plate had been loaded well into the post-buckled range, the panels tested had a high depth/thickness ratio. In addition, as far as the initial tests were concerned, it was decided to test panels having an aspect ratio $\alpha\left(=\frac{b}{d}\right)$ greater than 1·6 : 1, because with such panels at least two waves will be formed when the critical load is exceeded. Obviously, changes in the behaviour of two or more waves would be more easily noted than changes in a single-wave formation. In some of the later tests however, panels having smaller aspect ratios were tested to determine the effect of changes in this parameter.

Altogether 32 beams and shear panels were tested. These consisted of seven beams which were simply supported at their ends and centrally loaded, five cantilever beams and twenty shear panels. The shear panels and the cantilevers were tested in a special testing frame. The general method of loading the shear panels is shown diagrammatically in Fig. 8 on the following page, and Fig. 9 shows a panel in position in the frame.

It will be seen that the flanges extend beyond the panel and are connected at their ends by two straps. This was done to give some degree of continuity to the flanges, such as occurs in practice. Since the flanges and straps are only connected by pins (P) the panel carries the entire shear load. The framework is carried by two brackets BR1 and BR2 (see Fig. 8). The bottom bracket has a hole through which the pin connecting the lower strap and the near flange of the framework passes. The pin connecting the upper strap to the near flange passes through a slot in the top bracket. The two rollers R1 and R2 keep the framework in position.

TESTING PROCEDURE

Since the earlier tests on model girders had shown that with a change in flange rigidity completely different wave forms were produced in panels of similar superficial dimensions, it was decided that contour plots should be obtained of the wave formations in the panels at the initial

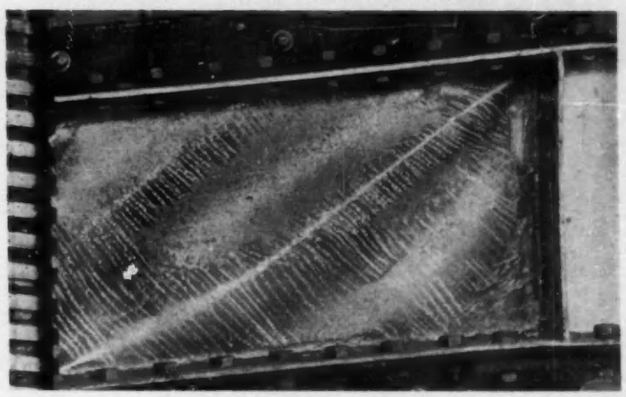
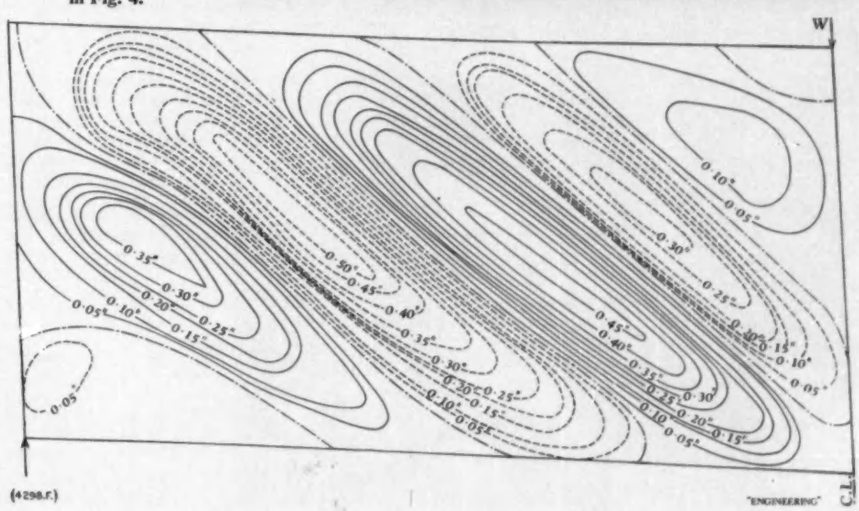


Fig. 6 (right) Stress distribution in web of girder with stiff flanges as obtained by a brittle lacquer, compare with that shown in Fig. 5.

Fig. 7 (below) Residual web deflections after test to failure of girder with stiff flanges. A uniform wave formation covers the whole of the panel in contrast with that shown in Fig. 4.



Continuing Design

buckling load and at each integer value of the ratio $\frac{W}{W_{cr}}$.

To obtain the contour plots two methods have been employed. In the earlier tests, a gauge bar was used which fitted over the bolts attaching the horizontal stiffeners to the web plate. By measuring the position of the web plate with respect to this gauge bar before testing and during the test, the movements of the plate were recorded. The deflections were determined with the aid of a dial gauge graduated in divisions of 0·0005 in. It is claimed as a result of tests made by a number of independent and impartial observers that deflections were determined to $\pm$ 0·001 in.

In addition to the wave plots, load/lateral buckled plate was obtained using the special frame shown in Fig. 10. The bar to which the dial gauge is attached can be adjusted to any position along the vertical guides, while the dial gauge could be moved to any position along the bar. With this frame it was possible to determine the deflection of the web plate at any chosen section throughout the test.

In addition to the wave plots, load/lateral deflection curves for the web plates were obtained by using a number of dial gauges which were in continuous contact with the web plate throughout the test, these gauges being capable of recording deflections of 0·0001 in.

Although some strain gauge measurements were taken, it was decided that unless a very large number of gauges were used on each panel, misleading conclusions could be obtained. For this reason, most attention was paid to obtaining good contour plots of the buckled surface of the web plate.

DISCUSSION OF TEST RESULTS

In all the tests it was found that the web plate started to deflect as soon as the load was applied, this indicating the presence of initial deformations. However, since great care had been taken in the manufacture of the shear panels and girders these initial deformations were small and, in general, the deflections of the web plates below the buckling load were considerably less than the thickness of the web plate.

The buckling loads, as obtained from the load/lateral deflection and load/strain plots, were very close to the theoretical value for clamped edges. This was to be expected,[9] since the minimum $\frac{t_f}{t}$ ratio employed was 2·2 to 1.

After an examination of the variables, it was considered that the best indication of the effect of flange flexibility would be obtained by plotting the parameter $\frac{\delta}{t}$ against the flange stiffness $\frac{I}{b^3t}$. From the contour plots the maximum value of $\frac{\delta}{t}$ for each multiple of the buckling load was obtained and plotted against the ratio $\frac{W}{W_{cr}}$

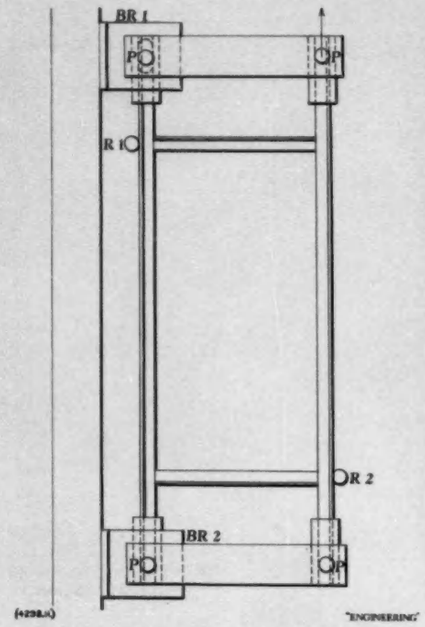


Fig. 8 Diagrammatically, the method of supporting and loading the shear panels.

as shown in Fig. 11. For the cases plotted in Fig. 11 it will be noted that as the stiffness of the flanges decreases so the value of $\frac{\delta}{t}$ occurring at any value of $\frac{W}{W_{cr}}$ increases. Fig. 12 shows how, for a given value of the load ratio $\frac{W}{W_{cr}}$, the value of $\frac{\delta}{t}$ varies with the stiffness of the flange. It will be noted that in each of these figures the values of $\frac{\delta}{t}$ are more or less constant until a certain value of $\frac{I}{b^3t}$ is reached, and that thereafter the value of $\frac{\delta}{t}$ increases rapidly with decreasing values of $\frac{I}{b^3t}$.

The full line plotted represents the considered best curve drawn through the points. With regard to the scatter of the experimental results it will be appreciated that the presence of initial imperfections means that the membrane stresses develop earlier. This will have a most marked effect on the behaviour of the panels with the more flexible flanges, and the result of this is that the position of the mean line is not too

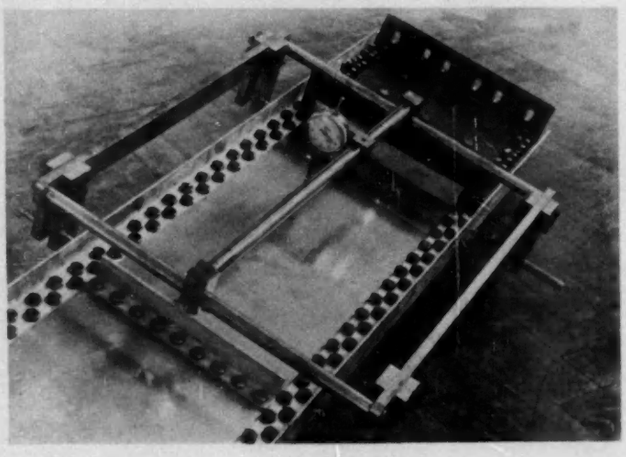


Fig. 10 (left) Apparatus used to determine contour plots of web, shown attached to cantilever beam. The dial gauge block can be moved in keyway to any position along horizontal bar which, in turn, can be adjusted to any position along vertical bars.

Fig. 11 (right) Experimental results showing how the maximum depth of the web buckles is affected by changes in the flange stiffness parameter $\frac{I}{b^3t}$.

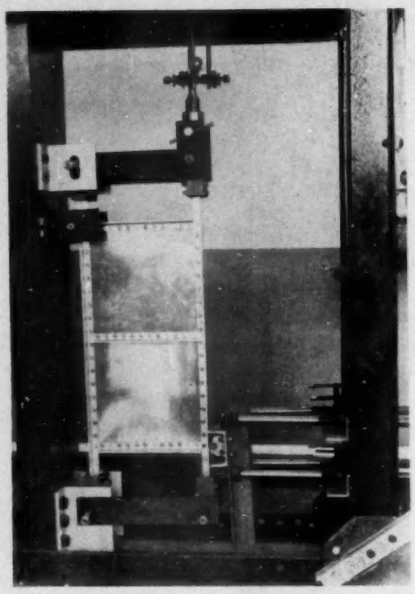


Fig. 9 Shear panel shown in position in testing frame.

well defined for the lower values of $\frac{I}{b^3t}$. The collected set of curves plotted in Fig. 13 has been obtained from plots similar to those given in Fig. 12. It will be noted that the minimum desirable value of $\frac{I}{b^3t}$, that is, the flange stiffness below which larger values of $\frac{\delta}{t}$ will be obtained, increases with an increase in the ratio $\frac{W}{W_{cr}}$. The considered minimum value for $\frac{I}{b^3t}$ for each value of the load ratio $\frac{W}{W_{cr}}$ is marked by a circle in Fig. 13.

These values of $\frac{I}{b^3t_{min}}$ have been plotted against the corresponding value of $\frac{W}{W_{cr}}$ in Fig. 14 and it will be seen that the relationship between $\frac{I}{b^3t_{min}}$ and $\frac{W}{W_{cr}}$ is given by the empirical law

$$\frac{I}{b^3t_{min}} = (0{\cdot}00035)\left(\frac{W}{W_{cr}} - 1\right) \quad . \quad . \quad . \quad (1)$$

valid over range $1 \gtrless \frac{W}{W_{cr}} \gtrless 4$.

It is perhaps of interest to note that if the empirical relationship given by equation (1) is used to determine the $\frac{I}{b^3t_{min}}$ for a well developed tension field, say the load ratio $\frac{W}{W_{cr}} = 10$, then the value of $\frac{I}{b^3t}$ obtained is not inconsistent

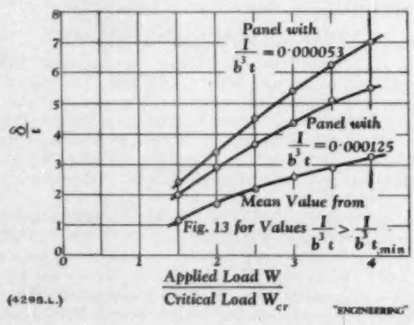
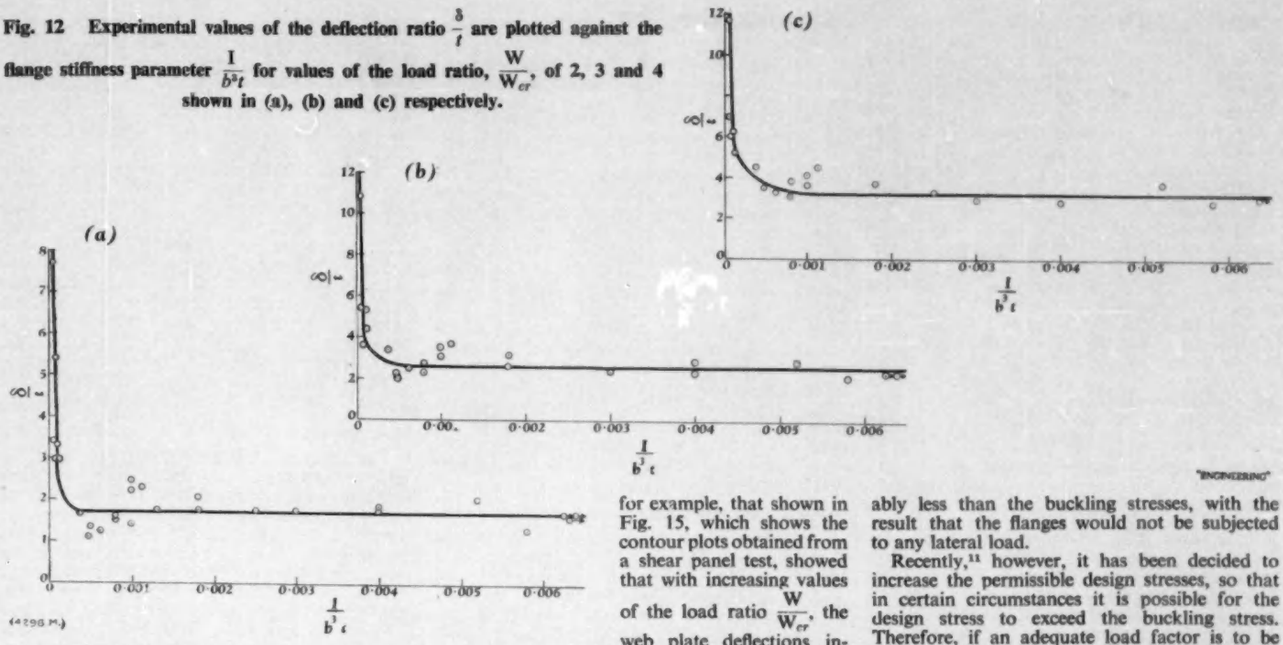


Fig. 12 Experimental values of the deflection ratio $\frac{\delta}{t}$ are plotted against the flange stiffness parameter $\frac{I}{b^3 t}$ for values of the load ratio, $\frac{W}{W_{cr}}$, of 2, 3 and 4 shown in (a), (b) and (c) respectively.



with the value obtained by Leggett and Hopkins[4] for such conditions. The empirical value being somewhat lower than the theoretical value, as is to be expected.

A study of the wave formations obtained, as for example, that shown in Fig. 15, which shows the contour plots obtained from a shear panel test, showed that with increasing values of the load ratio $\frac{W}{W_{cr}}$, the web plate deflections increase, the wave lengths decrease and the number of waves increase. It was hoped that an examination of the half wave lengths would have assisted in the analysis of the experimental results, but this was not the case. It was noted however, that there was a tendency for the panels with stiffer flanges to develop more half waves at any particular value of the load ratio $\frac{W}{W_{cr}}$.

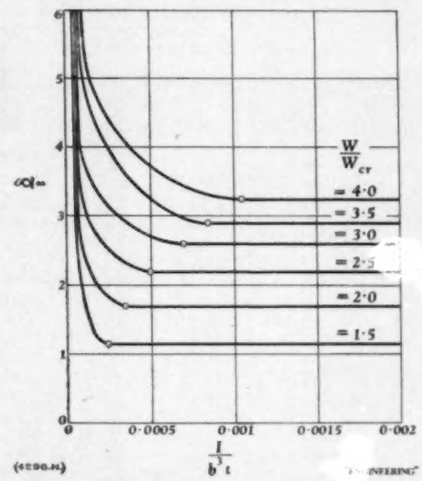


Fig. 13 Experimental relationships between deflection ratio $\frac{\delta}{t}$ and the flange stiffness parameter $\frac{I}{b^3 t}$ for different load ratios $\frac{W}{W_{cr}}$. Curves show how large deflections of web occur if flange stiffness is reduced below a minimum value $\left(\frac{I}{b^3 t}\text{ min.}\right)$.

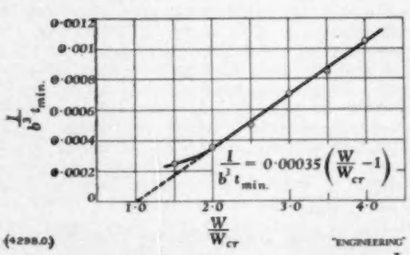


Fig. 14 Relationships between the values of $\frac{I}{b^3 t}$ min. obtained from Fig. 15 and the load ratio $\frac{W}{W_{cr}}$.

APPLICATION TO DESIGN

It has been established in the foregoing that if the flanges of a plate girder are flexible, then, when the web plate is loaded beyond its buckling load, the flanges will deflect under the lateral load imposed by the membrane stresses. In recent years, arc welding has become widely used in the construction of plate girders and it has been noted that many of these girders[10, 11] have been designed with flanges which have a stiffness as represented by the parameter $\frac{I}{b^3 t}$ which is well below the desirable values as indicated by the experimental investigation. For example, the $\frac{I}{b^3 t}$ value of the flange stiffener combination of the girder[10] of Fig. 2 is 0·000 059 which is extremely low. It is considered that many of these girders would fail shortly after being loaded beyond the buckling load of the web plate.

Many engineers will naturally ask the question, "Why are those girders which have flexible flanges operating satisfactorily in practice?" The reason is because the girders were designed so that the design shear stresses were much less than the buckling stresses of the web plates. Therefore, under normal service conditions, the plates would be operating at stresses considerably less than the buckling stresses, with the result that the flanges would not be subjected to any lateral load.

Recently,[11] however, it has been decided to increase the permissible design stresses, so that in certain circumstances it is possible for the design stress to exceed the buckling stress. Therefore, if an adequate load factor is to be obtained, it is essential that the flange-stiffness combination shall have sufficient rigidity to carry the lateral loads imposed by the membrane stresses.

In this connection, another important point which will have to be considered is that of limiting the permissible maximum initial deformations which can occur in a web plate, without the use of additional stiffening. The shear panels and plate girders tested in the laboratory were very carefully constructed but, nevertheless, all had small initial deflections, while some girders with thin web plates, not reported in the previous sections, had large initial deformations. The deflections occurring in these latter girders, which had stiff flanges, were considerably greater than the normal deflections.

It has been noted that many welded girders have quite large initial deformations[12] and it

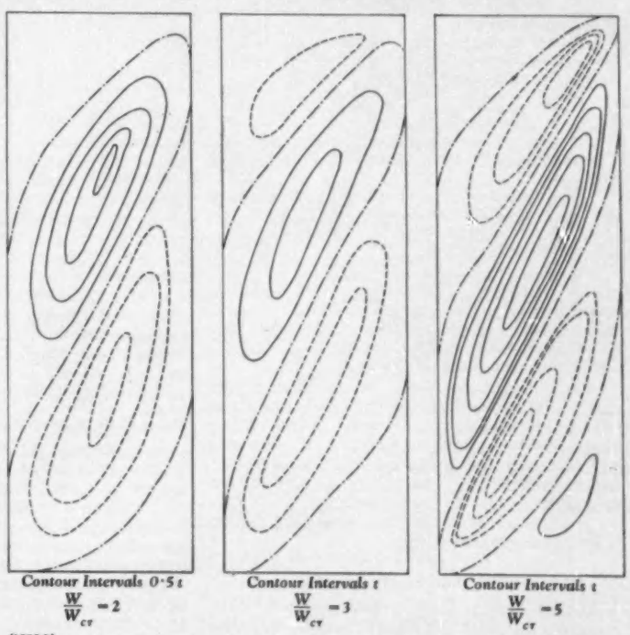


Fig. 15 Contour plots obtained from tests on a shear panel, illustrating how the number of waves, and their depth and shape, alters with increasing values of the load ratio $\frac{W}{W_{cr}}$.

Continuing Design

must be appreciated that when such girders are loaded the membrane stresses are set up immediately and the effect of flange flexibility will become evident at a lower load. It is suggested as a result of experience, that no web plate having an initial deflection greater than half its thickness shall be allowed to operate beyond its buckling load. This recommendation may appear rather drastic, but the effects of initial imperfections upon the behaviour of web plates can be quite considerable. The above recommendation could be easily applied in practice, by introducing an additional stiffener when on inspecting a panel it is found to be badly deformed.

It has been seen that, if the web plates of plate girders are to develop full strength, the stiffness of the flanges should not fall below the values given in equation (1). To allow for the presence of initial irregularities, it is suggested that, irrespective of the operating stress, no girders should have a flange stiffness, as represented by the parameter $\frac{I}{b^3 t}$, less than 0·000 35.

CONCLUSION

It is hoped that the above recommendations will result in the design of more efficient plate girders. In this connection, since the laboratory tests are, of necessity, conducted on relatively small girders, it would be of considerable interest if practising engineers were to measure the initial deformations occurring in the web plates of large plate girders and to also measure the deflections occurring under normal load conditions. If any figures were communicated to the author, he would be very grateful.

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★ ★ ★

A bunsen burner for use with gases of high calorific value, such as propane, butane, methane, natural gas or sludge gas mixtures is now being marketed by Amal Limited, Witton, Birmingham, 6. Known as the "3 Jet Maximus," it will liberate something over 3,000 kg. calories per hour at normal gas pressures.

Atomic Review

Materials Miscellany

THE application of atomic energy is intimately associated with the problems of metallurgy. The further development of nuclear reactors, for example, depends less upon increased knowledge of nuclear science or more ingenious arrangements of fuel, coolant and moderator, than upon the discovery of materials resistant to corrosion in a variety of unsavoury atmospheres. The link between material defects and corrosion is self-evident, and the first six sections of the present article, which deals generally with materials problems is devoted to reports on six papers presented at a symposium on "Vacancies and Other Point Defects in Metals and Alloys," organised by the Metal Physics Committee of the Institute of Metals, 17 Belgrave-square, London, S.W.1. The symposium was held in the Cockcroft Hall at the Atomic Energy Research Establishment, Harwell, Berkshire, on December 9 and 10.

Defects Near the Metal Surface

In studying surface phenomena in metals, complications arise because the surface is not a simple boundary between two phases, the metal and its environment, with the internal structure and properties of the former persisting unchanged right up to the ultimate atomic demarcation. Disturbing factors are introduced by the contamination of the surface and underlying layers, and by defects in the structure of these layers which are particularly sensitive to the method of preparing the surface. In the terminology of the present symposium, point defects, which are taken as including atoms of impurity and of solute elements in small concentrations, appear to be of special significance in a variety of surface phenomena. The field is a very wide one and the purposes of the symposium are perhaps best served by describing some recent observations, which emphasise the importance of point defects more particularly in the oxidation of metals.

In the course of an investigation into certain fundamental aspects of corrosion, observations have been made indicating appreciable concentrations of impurities at the surface of commercial copper as a result of diffusion from the interior during annealing. These concentrations have been found to have a considerable effect on the rate of oxidation at room and elevated temperatures.

The role of oxide films in the corrosion of metals in aqueous electrolytic environments is understood only in a crude qualitative manner, but it is recognised as being a very important one. Here, point defects should be considered because of their influence on ionic and electronic transport phenomena in oxides. With the object of studying oxide films on metals from this point of view, an investigation of the optical properties of oxide films, grown under controlled conditions of temperature and oxygen pressure on copper and some binary alloys, has been carried out. ("Point Defects near the Surface of a Metal": Mr. E. C. Williams and Mr. P. C. S. Hayfield, Imperial Chemical Industries Ltd., Metals Division, Birmingham.)

Point Defects and Diffusion

A knowledge of the mechanism of diffusion in any given crystal is an essential prerequisite to the understanding of most of the high-temperature properties of the material. Creep, polygonisation, sintering, internal friction, and precipitation all involve, to varying degrees, the transport of atoms through the crystal lattice.

In a pure material, self-diffusion can be observed by using radioactive tracer atoms of the same chemical species. In the high-temperature region, vacancy or interstitial diffusion may give measurable mass transport (diffusion creep), and in suitable circumstances this can be measured.

The transport of atoms through a crystal may conceivably occur in several ways. The term interstitial diffusion is used of systems in which the moving atom does not lie on the crystal lattice, but instead occupies an interstitial position. The term vacancy diffusion is used when the mode of progression of an atom through the lattice takes the form of movement to an adjacent vacant lattice site. The term, ring diffusion, has been coined to cover all possible interchanges of atoms in a region of perfect lattice. The work of N. H. Nachtrieb and his collaborators suggests that the elementary activation event may be local melting and the interchange of atoms in this melted region. ("Point Defects and Diffusion in Metals and Alloys": Dr. W. M. Lomer, A.E.R.E., Harwell.)

Ionic Crystals

The study of the mechanical properties of ionic crystals has become increasingly important in recent years, because it is now possible to etch and to decorate the dislocations responsible for plastic deformation in a fairly simple manner. Furthermore, in ionic crystals point defects are responsible for the electrolytic conductivity. In addition, the majority of these crystals are transparent over a range of wavelengths from infra-red to ultra-violet, and optical techniques give valuable information regarding the presence of long-range internal stresses.

The types of ionic crystal principally studied in the present research have been the alkali halides and the silver halides, all of which crystallise in the sodium chloride structure. This consists of a simple cubic array of alternate positive and negative ions, each surrounded by six nearest neighbours of opposite sign. Both positive- and negative-ion vacancies can exist, and, since each vacancy carries an effective charge of opposite sign, they will occur in equal numbers to maintain electrostatic neutrality in the crystal.

The author concludes: (1) The density of vacancies in annealed crystals depends critically upon the temperature of annealing and upon the subsequent rate of cooling. This density varies from about 3×10^{16} per cub. cm. in a well-annealed crystal to a maximum of 10^{19} per cub. cm. Most of these vacancies are in the form of pairs or clusters in random solid solution, and only about 5 per cent. are associated with dislocations. (2) Vacancies are generated by plastic deformation once past the limit of easy glide. Measurements by widely different techniques indicate that a density of 2×10^{16} per cub. cm. is created by each additional 1 per cent. strain, up to total strains of at least 10 per cent. at room temperature. (3) Dislocations are pinned by vacancies at room temperature. The pinning of freshly-created dislocations is aided by disrupting nearby clusters of vacancies in the lattice, either by X-irradiation or by raising the temperature to 200 deg. C. (4) Vacancy pairs and clusters exert a small solid-solution or dispersion-hardening influence, which, together with the pinning, is responsible for the yield strength of annealed crystals. (5) Heavily-jogged dislocations increase the yield strength to about three times the annealed value at normal rates of strain, but move more easily at low rates of strain. (6) Dislocations in ionic crystals carry a positive charge determined by the differing energies of formation of positive- and negative-ion vacancies. This charge is screened by a cloud of oppositely-charged vacancies, which contributes to the pinning of the dislocations. ("Point Defects and Mechanical Properties of Ionic Crystals": Dr. P. L. Pratt, Department of Physical Metallurgy, University of Birmingham.)

Point Defects and Mechanical Properties

The effects of vacancies at high temperatures are now widely recognised; self-diffusion, diffusion in substitutional solid solutions, and many processes of solution, precipitation, and coarsen-

ing in solid solutions depend on the movements of vacancies. Similarly, vacancies enable dislocations to climb over obstacles in their slip planes, and this is one of the reasons why metals become soft and lose their resistance to creep at high temperatures.

The effects involving vacancies and other point defects, now to be discussed, are those which appear at temperatures too low for normal lattice diffusion to play a significant part. These effects include such matters as the hardening and embrittlement of metals by nuclear radiation, certain aspects of the strength of intermetallic compounds and of fatigue deformation in metals and alloys, and ageing processes in cold-worked alloys. There are four methods of introducing point defects into metals and alloys at temperatures below the range of self-diffusion, namely, irradiation with atomic particles of high momentum; quenching from high temperatures; controlled deviations from stoichiometry in certain intermetallic compounds; and plastic deformation.

The evidence examined during the present investigation has led to three main conclusions: (1) Soft metals can be hardened by point defects. Apart from radiation-hardening experiments, the best evidence for this is the age-hardening observed in pure metals after quenching. (2) Excess vacancies migrate to dislocations and anchor them. This is shown by the accentuation of annealing in quenched metals by cold work, and by the suppression of dislocation damping in soft metals by irradiation or quenching. (3) Cold work creates point defects. This is shown by low-temperature annealing experiments and by the stimulation of low-temperature ageing processes in super-saturated alloys.

Several other conclusions appear sound. There is little doubt that work-hardened or precipitation-hardened metals can be softened by point defects; and, conversely, that metals hardened by point defects can be softened by plastic deformation. The evidence for the latter is provided by the yield drops, coarse slip lines, overshooting, and changes of texture observed when metals hardened by point defects are worked. The hardening of ionic and intermetallic compounds by deviations from stoichiometry also suggests the influence of point defects, and in fatigue there are many signs that these defects play a vital part in the process. (" Point Defects and the Mechanical Properties of Metals and Alloys at Low Temperatures ": Dr. A. H. Cottrell, F.R.S., A.E.R.E., Harwell.)

Fig. 1 Battery of 12 units installed in the Erith laboratories of the General Electric Company's Atomic Energy Division for preliminary creep and stress-rupture tests on reactor materials.

Lattice Defects and Physical Properties

According to theory, the vacant lattice site is the only species of lattice defect that is ever present in appreciable concentration in thermodynamic equilibrium in a noble metal. By quenching, by irradiation, and by plastic deformation, however, it is possible to introduce defects into a metallic lattice in excess of the equilibrium concentration. Thus, although several species of defect are often produced simultaneously, it is possible, in principle, to discriminate between them by means of annealing experiments at increasing temperatures, during which successive changes in physical properties are measured as the concentration of each species decreases.

The three most useful and important physical properties which may be used for the study of lattice defects in metals are: stored energy, electrical resistivity, and density. The energies associated with vacancies, interstitials, and dislocations in copper, silver, gold and nickel are known to within a factor of 2. Density changes caused by vacancies are known relatively precisely, but the theoretical values for interstitials and dislocations are rather uncertain.

The production of defects during heavy-particle bombardment and during deformation is imperfectly understood. Fairly precise models have been used for the calculation of defect concentrations likely to be generated by bombardment at low temperatures (say below 20 deg. K.), but the results appear to be in error by a factor of 5.

It is probable that slight traces of impurity can trap point defects; the physical properties of defect-solute pairs merit study, since few experiments have been carried out with metals so pure that any possible effects of impurities can be wholly disregarded. (" The Effects of Lattice Defects on Some Physical Properties of Metals": Dr. T. Broom and Mr. R. K. Ham, Department of Industrial Metallurgy, University of Birmingham.)

Point Defects and High-temperatures

The point, or near-point, defects now to be considered are foreign atoms, vacancies, jogs and constrictions in dislocations, and ledges along grain boundaries. These appear to be the defects chiefly concerned in unidirectional plastic deformation (creep) and fracture at elevated temperature.

Creep at high temperatures seems to be governed in most metals by the rate of climb away from obstacles. In single-phase metals the obstacles are presumably the stress fields of other dislocations, and in most commercial creep-resistant alloys they take the form of small particles of a second phase. In pure metals the climb model provides an acceptable interpretation of the qualitative and quantitative data in some cases, but the details are obscure and anomalies occur. In complex alloys, only a qualitative interpretation is possible.

Two kinds of intergranular fracture in creep are possible; one is the development of cracks at grain corners and the other is the development of cavities at ledges in grain boundaries. The characteristics of these two processes appear to differ somewhat and there are a number of factors which may influence the predisposition of a metal to intergranular fracture. (" Point Defects and the Mechanical Properties of Metals and Alloys at High Temperatures ": Dr. D. McLean, Metallurgy Division, National Physical Laboratory, Teddington, Middlesex.)

Disposal of Radioactive Wastes

In a paper presented before the annual conference of the American Industrial Hygiene Association, held this year, Mr. J. F. Newell, of the United States Atomic Energy Commission, stated that in the disposal of highly radioactive aqueous wastes, two general approaches were being followed. One was to explore the feasibility of concentrating and fixing the radioactive waste material, namely, the actual fission products, in a stable, solid medium so that the possibility of the migration of the radioactivity into the surroundings would be eliminated or reduced to safe limits. The medium containing the radioactive material could then be stored or buried permanently.

It appeared firstly, that with wastes containing high salt concentrations (such as aluminium nitrate wastes from processing U-Al alloy fuels) conversion, by heating, of salts and fission products to a solid-oxide form was in itself a desirable waste-handling scheme and was also a useful step in an ultimate disposal system. This system would involve the leaching of the oxide and the further fixation of the leached product. Secondly, it might be possible to utilise the decay heat in highly radioactive wastes to self-sinter a mixture of aqueous wastes and natural earth materials. In the third place, the fixation of radioactivity in synthetic feldspars (activated hydrated aluminosilicates) appeared promising.

The other approach for the disposal of the wastes, upon which less work had been done, involved the discharge of the aqueous wastes, essentially untreated, into specific underground geological formations such as salt domes and strata, deep synclinal basins, specific shale formations and certain porous sedimentary strata. Research work on these lines was proceeding.

Welding Uranium

Investigations on the welding of uranium are stated in a paper in the September issue of the *British Welding Journal*, by Mr. J. R. C. Gough and Mr. D. Roberts of the Atomic Weapons Research Establishment, Aldermaston, Berkshire, to have been largely exploratory in character. The authors have studied the applicability of the argon-arc, metal-arc, and resistance spot-welding processes. The results of their work show that uranium can be satisfactorily welded by the argon-arc process, and the weld metal is stronger and harder but less ductile than the parent metal. The maximum penetration obtainable is of the order of $\frac{1}{16}$ in. Metal-arc welding is at present unsatisfactory, but continuous inert-gas-shielded metal-arc welding may be feasible. The metal transfer of molten uranium in metal-arc welding is coarsely globular; high current densities may promote spray transfer but cause rapid overheating and the consequent distortion of the uranium electrode in the soft, plastic γ-phase. Thin alumina coatings reduce the surface tension significantly but do not appear to affect the mode of metal transfer.

The results of weldability tests have shown that the susceptibility of uranium to hot cracking is very low. These findings confirm the experience obtained in casting, namely, that unalloyed uranium is not at all hot-short. Uranium in the form of thin sheets is readily joined by resistance spot welding.

Creep Testing at G.E.C.

New research equipment designed to provide preliminary creep and stress-rupture data on metals and alloys in gaseous atmospheres and at high temperatures and pressures has recently been installed in the materials research laboratory of the General Electric Company, Limited, Atomic Energy Division, Erith, Kent. The new plant is intended for work in connection with the company's gas-cooled reactors. The twelve

Continuing Atomic Review

creep-testing units seen in Fig. 1 have already done valuable basic work in investigating the properties of magnesium alloys, widely employed for fuel-element cans, in carbon dioxide atmospheres. They can be readily converted for work on other materials in other gases.

In the new equipment, the specimen, the whole of the stressing apparatus and the associated extensometer are enclosed in a vertical cylindrical pressure vessel, shown in section in Fig. 2. This, in turn, is enveloped along part of its length by an electric furnace. The body of the pressure vessel, which is of stainless steel $\frac{3}{16}$ in. thick, is approximately 5 ft. long and has an internal diameter of 4 in. At its open upper end it is provided with a machined facing flange. The top plate of the vessel is bolted down to a loose flange slipped over the vessel body, a Klingerit gasket being inserted between the top plate and the facing flange to ensure gas-tightness.

The upper end of a support rod, from which the specimen is suspended, is welded to the centre of the top plate, while its lower end is provided with a pivoted coupling, a similar coupling being fitted to the top of a pull-rod. Alternative couplings are available so that specimens of either rectangular or circular cross-section can be used. A cylindrical cup, which is a loose fit in the pressure vessel, is welded to the support rod between the top plate and the coupling and is filled with refractory cement so as to provide heat insulation above the operating section.

Loading weights are mounted on a plate welded to the lower end of the pull-rod. To the underside of this plate is attached a bracket carrying a dial gauge, the operating head of which rests on the end of a bolt passing through the bottom plate of the pressure vessel by way of a rubber gas seal. The bolt serves as a zero-setting device for the gauge. The gauge reading can be observed through a pressure- and heat-resistant glass window mounted between soft rubber gaskets in a tube welded into the side of the pressure vessel. A stop is provided beneath the gauge mounting to prevent excessive travel of the pull-rod, which might damage the gauge, in case of rupture of the specimen.

Gas is admitted to the pressure vessel through a tube of $\frac{1}{4}$ in. internal diameter passing downwards through the top plate and the refractory cement plug. A gas outlet tube, of the same diameter, is welded into the side of the vessel below the operating section.

The electric furnace surrounding the pressure vessel is of 4 kW and is built in two sections. It can be split by unbolting two vertical clamping plates, thus allowing the pressure vessel to be removed. The Nichrome heating elements are carried in slots in the inner faces of bricks of high-temperature insulating material and give a satisfactory temperature distribution in the region of the specimen. The total duration of the test varies according to the particular requirements, but is normally between 150 and 1,500 hours.

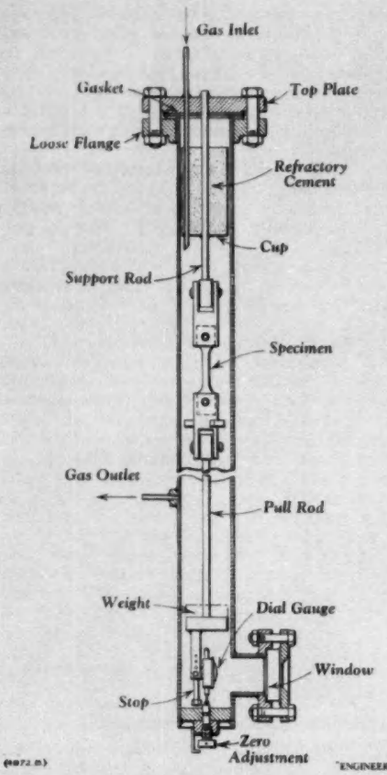


Fig. 2 Cross-section through the pressure vessel of one of the units of the creep-testing apparatus for investigating the creep and stress-rupture properties of metals and alloys, in gaseous atmospheres, at high temperatures and pressures.

Applications of Isotopes

Applications of radioactive isotopes noted in United Kingdom Atomic Energy Authority literature during the year.

Coastal Erosion.—The movements of pebbles on beaches and under coastal waters have been traced using natural pebbles in which holes have been drilled and filled with resin pellets "labelled" with barium 140 and lanthanum 140. The movement of the pebbles after putting them into the sea is traced by portable detectors. This method of labelling is somewhat tedious and methods for impregnating the surfaces of pebbles with other isotopes (including silver 110 and gold 198) have been developed. In a field trial using 2,000 pebbles labelled on the surface in this way, 6 per cent. of the pebbles were recovered after two days and another 3 per cent. after three weeks (during which time some of the pebbles had moved a mile). At least ten times more pebbles were recovered by this method than is possible when painted pebbles are recovered by visual means, and the method opens new possibilities in studies of coastal erosion and build-up. This work has been done in conjunction with the Nature Conservancy.

Contaminants in Oils.—A cheap method has been developed for continuously determining sulphur and lead contaminants in liquid hydrocarbons in oil processing. In this method, the measurement of the absorption of the braking radiation, or *bremsstrahlung* (from standard preparations of radioactive tritium on zirconium foils), by the contaminants gives an indication of the amount of contamination.

Processes.—Radioisotopes have been used as tracers to measure the material throughput rates, hold-up, and recirculation in cement and fertiliser plants; the analysis of charts from recording meters show the recirculation percentage and period as well as the rate of movement and spread of the added material. Other industrial applications have included a self-adjusting gauge (using a thulium 170 source) to indicate continuously the liquid level in enclosed pipes, and a compact gauge to be used in a borehole for underground measurements of soil density over a wide range.

Tritium as a Tracer

Work at the Argonne National Laboratory, U.S.A., on the use of tritium as a tracer is discussed below.

It is pointed out that β-emitting tritium has great potential value as a radioactive label of molecules since it allows the tracing of many specific compounds through a plant or animal, or through an industrial process. Its use has been restricted in many cases because the introduction of tritium into a specific molecule by conventional synthetic methods has proved difficult or even impossible. The discovery at Argonne that organic compounds can be labelled with this radioactive hydrogen merely by exposure to tritium gas may be expected to lead to the increased use of tritium in tracer studies. It is stated that, to a surprising extent, the tritium β-radiation catalyses the exchange of tritium with ordinary hydrogen atoms in the organic compound. Materials of complex, or even unknown, structure can be labelled readily in this manner, and concentrations of tritium, which it is possible to analyse after a million-fold dilution, can be introduced. The simplicity of the technique and the low price of tritium makes its large-scale use in industrial research economically feasible.

Materials Safeguards

The U.S.A.E.C. has invited comment on a proposed regulation to guard against accidental conditions of criticality in the shipment of special nuclear material. While there could be no bomb-like explosion in such a case, there might in cases of sufficiently large shipments be spread of radioactive material in the vicinity. Requirements to protect against accidental conditions of criticality have been incorporated in the past in specific licensing actions. Limits would be placed in the proposed regulation on the amounts of plutonium, uranium 233 and uranium enriched in the isotope uranium 235 which a licensee might transport or deliver to a carrier for a single shipment. Shipments in excess of these limits would be permissible only after approval by the Commission. The limits are shown in the table below.

Safety Limits for Transporting Nuclear Materials

Nuclear material	Transportation by a Licensee (any one of the following)	Delivery to a Carrier (any one of the following)
Uranium enriched in the isotope Uranium 235	350 grams contained Uranium 235	100 grams contained Uranium 235
Uranium 233	200 grams	60 grams
Plutonium	200 grams	60 grams

Formulae would be provided in the regulation for determining permissible amounts in mixed shipments. The prescribed limits are based on a study entitled "Estimated Critical Masses of Diluted Oralloy" and on "A Guide to the Calculation of Criticality Limits for Enriched Uranium." These reports are available for examination in the Commission's Public Document Room at 1717 H-street, N.W., Washington, D.C.

Lubrication for Nuclear Power Stations

Lubrication problems at nuclear power stations are, generally speaking, not dissimilar from those at conventional stations. The main point of difference is that some lubricants in part of an installation are liable to degradation through exposure to radiation. The Wakefield Group has been working on these problems for some time, and has been awarded contracts, which have been placed with Wakefield-Dick Industrial Oils Limited by the Central Electricity Authority and the United Kingdom Atomic Energy Authority, for the lubrication of the power stations at Berkeley and Chapelcross.

The fission process produces four types of particle or radiation—alpha, beta, and gamma and neutron radiations. Of these the first two are generally harmless to lubricants as they are absorbed by the structure and shielding of the pile. Gamma radiation and neutrons can have the effect of thickening lubricating oils to a point at which they are unserviceable, while greases can be similarly affected to produce hard solids. The viscosity increase appears to occur in two stages; in the first, the oil may be only slightly thickened while grease may actually become softer but, in the second stage, viscosity increase and solidification proceed more rapidly and the lubricant may be rendered useless. Useful information has been obtained and certain types of petroleum-based lubricants have been shown to resist the thickening effect more strongly than others, while certain materials not of petroleum origin have shown considerable promise. Gas bearings are an alternative solution.

High-Purity Thorium

A solvent extraction process is reported to have produced thorium with a purity of 99·89 per cent. Developed at the Battelle Memorial Institute and reported at a meeting of the American Chemical Society, the process involves the treatment of thorium nitrate, and is said to be the only practical means discovered so far of producing thorium of sufficient purity for use in reactors. Thorium is much more abundant than uranium, and though it is not itself fissile it is the source of fissile uranium 233. The new discovery may prove to be a significant factor in the economics of reactor selection.

Radiation Windows

Windows capable of withstanding high levels of radiation are being developed by the Mendip Chemical Engineering Company, Limited, Ashford, Kent, one of the Pilkington groups of companies, from special glass made by Pilkington Brothers Limited, St. Helens, Lancashire. Special stabilised and unstabilised glasses of 2·5 or 4·3 specific gravity are built into a plastics shell reinforced by glass fibre to form a composite window sufficiently thick to provide the necessary protection. Up to 30 individual glasses each 1 in. thick have been used, the slight spaces between the glasses being filled with a liquid having the same refractive index as the glass to overcome multiple reflections from the glass surfaces. Alternatively, the windows may comprise a tank filled with a zinc bromide solution and having at each end single glass plates (or double glasses for additional safety), the glass at the "hot" or inner end being stabilised and that at the outer or observer's end unstabilised.

General Notes

Isotope Transporting Cans and Lead Shielding

The range of isotope transporting containers made by Savage and Parsons Limited, Watford, Hertfordshire, is described and illustrated in the company's leaflet No. 7/3. The lead containers are made to the design and specifications of the United Kingdom Atomic Energy Authority, and are used to carry isotope cans and other similar vessels in common laboratory use, enabling radioactive and toxic materials to be transported safely outside protected areas.

Atomic Icebreaker

It is reported that the Soviet nuclear-powered icebreaker "Lenin" has been launched. The vessel is to be propelled by a pressurised-water reactor power plant.

Nuclear "Great Eastern"

A comparison between the transition from sail to steam and that from conventional fuel to nuclear fuel was drawn in a letter to *The Times* recently. The writer, Mr. E. H. W. Platt, quoted Sir Christopher Hinton's reference to Brunel's courage and foresight in building the Great Eastern. In spite of her great failure the ship opened the way to our maritime supremacy in the first half of this century, wrote Mr. Platt. He went on to say that nuclear engineering might well be the most significant maritime development of the coming decades: a new Great Eastern could play as great a part in maintaining our supremacy at sea during the next hundred years as did her predecessor in establishing that supremacy.

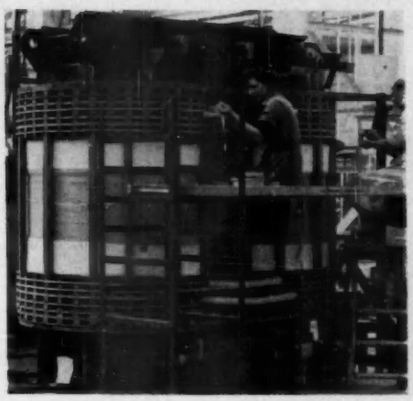
The writer acknowledged that the scope of technology required for such a project had grown beyond the grasp of a single man, and its financing had outgrown the resources of private backers; the financial support necessary could only come from the Government. However, he wrote, even setting aside possible strategic reasons, there appears to be every justification for raising our efforts in this field above the sterile level of paper studies and examining committees, and entering an active phase worthy of our great predecessors in the world of engineering achievement.

Production

TRANSFORMER FACTORY

As a result of continued expansion, the Metropolitan-Vickers Electrical Company, Limited, Trafford Park, Manchester, have constructed a new works at Wythenshawe, designed in the first instance for the manufacture of transformers. The new factory was opened on November 22 by His Royal Highness the Duke of Edinburgh. The scheme, of which the Wythenshawe factory forms part, provides for an increase of about 50 per cent. in the facilities at Trafford Park for building rotating machinery.

The new works is designed as a self-contained factory for all ranges of transformer, both power transmission and instrument types, together with the associated tap-changers, and also for power rectifiers. The works covers 28 acres of a 40-acre site, the present building having a floor area of 285,000 sq. ft., with an additional 75,000 sq. ft., for offices and canteens. It is designed to expand by the addition of three more bays, and the extension of the present five by 50 per cent. Site clearance began in August, 1954, and the main building was completed in December, 1956. At present, the factory employs 1,250 people, of whom 210 are women, and the total will rise to about 1,500 as the output expands. The works stands on the edge of a large new residential area housing 500,000 people, and will have direct rail connection with the Manchester overspill schemes in mid-Cheshire.



For medium and large power transformers, lightweight movable staging is employed to reach the upper portions.

Transformers of all sizes are made. The coils are wound on machines of the company's own design and may be as much as 10 ft. in diameter.

Any transformer within the limitations of road transport can be constructed and, for the purpose of moving them within the works, the two 120 ton overhead cranes are provided with a lifting beam to couple them together, giving a working load of 240 tons. The beam has alternative means of suspension, either from a central hook which can carry the full load, or from two spaced hooks designed for half the load each. The two hooks can be adjusted for width so that the lifting points on the load can be well spaced out. At the other end of the range of manufacture come the miniature potted transformers of the type used in instruments.

The plates from which the core laminations are made are annealed in batches in an atmosphere of cracked ammonia. (This applies, of course, to those plates which are made from cold-rolled steel.) After annealing, the plates pass through a varnishing plant of the continuous conveyor belt type. Both sides of the plate are varnished. Cores built up of paper-insulated plate are also constructed, but it is expected that those made from cold rolled, grain orientated steel will become the major part of the output as the material becomes more readily available.

The coils are wound on metal formers mounted in machines of the company's own design, using layer winding. Coils up to 10 ft. in diameter can be made. A control cutter shapes the paper insulation so that the thickness between layers varies along the coil corresponding to the potential difference. The transformer cores are first built up complete and then the top link removed to allow the coils to be slipped in place. Youngman lightweight staging is used by the workers to reach the higher portions of the transformer. When the coils are in place, the upper link is replaced in position.

The bays are arranged so that item production flows continuously along each one, and feeds across into the central bay for final assembly. For drying out the assembled transformers, there are hot air ovens, one of which has a roller top to make handling easier.

The completed transformers are tested electrically in the test bay, which is supplied with power from the sub-station. A 15 step impulse generator, operating at 2,500,000 volts, and having a discharge energy of 67,000 joules, is used for the impulse testing of the transformers. A two-metre sphere gap and a potential divider are included for voltage measurement, together with cathode-ray oscillographs and a dark room. Transformers under test as well as the test equipment are controlled from a gallery running the full length of the test area

Continuing Production

and the impulse generator from a cubicle at ground level.

The tanks for the transformers are fabricated in the end bay, which is the only one that is comparatively sealed off from the others by a glass partition. The assembled transformer is painted by the simple process of hosing it with a supply of paint, while standing over a drip area; three coats of different colours are used.

The auxiliary services for the factory include compressed air at 100 lb. per sq. in., and piped oxygen and acetylene at pressures of 100 lb. per sq. in. and 9 lb. per sq. in., respectively. In addition to the main overhead cranes there are a large number of power operated jig cranes over the different working areas. The factory is heated by a high pressure hot water system operating in radiant heat panels. The architects responsible were Metropolitan-Vickers Works Engineers' Department, and the main contractor for the building was George Wimpey and Company, Limited, Salford 5, Lancashire.

METHODS OF CLEANING BOILERS

It was in 1945 that the Boiler Availability Committee issued their first bulletin. This was entitled "Methods of Cleaning Modern Stoker-fired Boiler Plant," and some 5,000 copies have been issued to power station engineers at home and abroad. During the intervening years conditions have altered very greatly, particularly as regards the use of pulverised fuel. In 1945 the amount burned was insignificant but by March, 1957, it represented 57 per cent. of all fuel burned in British power stations.

Now, therefore, a new bulletin has been issued which not only is a revision of the earlier one but has also been made to cover pulverised fuel plants as well as stoker-fired boilers. The bulletin is available from the committee's offices at 8 Waterloo-place, Pall Mall, London, S.W.1.

The Boiler Availability Committee, the chairman of which is Mr. F. W. Lawton, works in close liaison with the A.S.M.E. committee concerned with corrosion and deposits, and also with Electricité de France, B.C.U.R.A., and the Fuel Research Station. Investigations on a laboratory scale at the works of many boiler makers, and on a large scale at several power stations, have led to the development of many new instruments for the determination of the nature of the deposits, as well as the flue gases.

The bulletin itself, after an historical note and an introduction, proceeds to deal with the nature of the deposits involved. This section is again divided into those which occur in the boiler itself, those which are found in the economiser and those in the air heater.

Sections 2 and 3 are concerned respectively with "On-load" and "Off-load" cleaning. With the high ratings and high temperature of the modern boiler some form of routine soot-blowing is essential. This is accentuated by the poor quality of many fuels now in common use. Examples of several types of blower are described and illustrated. The breaking up of deposits on high-temperature surfaces by lancing with cold-water jets is now an accepted method but requires judicious use to avoid damaging mild-steel tubes. Shot cleaning is also described.

"Off-load" cleaning, the subject of section 3, represents the action to be taken at the annual overhaul of the boiler. Rather different methods are therefore possible, including water sluicing, and spray and steam soaking. At the end comes a summary of the recommendations of both sections. The particular methods required for the removal of phosphatic deposits from the economiser and for cleaning rotary air heaters are dealt with in two appendices.

RETAINING ACCURACY IN COPY-DRAWINGS

Numerous machines now exist which reproduce, by grinding, flame-cutting or other means, a profile which is copied from a drawing by means of a tracer head. Very accurate work can be done by such machines, but it is obvious that the accuracy can only be maintained or, in fact, initially achieved, if the material on which the drawing is made is consistent and stable.

A special projection drawing board has therefore been introduced for this purpose by John Dickinson and Company, Limited, Card and Board Department, Apsley Mills, Hemel Hempstead, Hertfordshire. It has a stretch-resisting layer of aluminium foil sandwiched between two sheets of specially prepared high-grade paper, and is based on extensive experiments conducted in liaison with users.

Tests carried out by the Naval Architecture Department of Sunderland Technical College have shown that dense and uniform lines of any thickness could be drawn on the board, and that lines could be erased repeatedly and re-drawn in ink without fear of spreading. It has also been demonstrated that the board will withstand heating and water-immersion tests without losing its stability in respect of the lines drawn on it. The board is available in widths of 20 in. and 21 in., any length can be supplied.

Construction

RE-BUILDING AFTER THE JAGUAR FIRE

Much has been written about the disastrous fire at the works of Jaguar Cars, Limited, Coventry, on the night of February 12, 1957*; however up to the present no detailed information has appeared on the steps which were taken to get the factory back into production. Many things had to be done, including some of a temporary nature, and the whole complex operation was characterised by the speed at which it was carried out.

PLAN FOR REPAIRS

Contact was made with the structural engineers and roofing contractors on the night of the fire. On the following morning representatives of these firms met Jaguar officials in the works, and in daylight it was possible to see what damage had occurred, and to make plans for repairs where possible and for replacement elsewhere. The factory is 400 ft. wide, in five spans of 80 ft., with a 30 ft. flat-roofed annexe at each side. Damage extended over the whole width of the factory at the north end, and for a distance of 390 ft. towards the south; an area of approximately 400 ft. square at the north end was thus put out of commission. Of this area some parts were completely destroyed and the remainder badly damaged. There was superficial damage in some three further bays, but neither of the flat-roofed annexes was affected. It was decided that some parts of the factory could be made usable by means of temporary repairs, and that others would have to be demolished completely and replaced. Repairs and reconstruction were planned to take place in three major stages, the first two of which could be carried out simultaneously.

The first step was to effect temporary repairs to those parts of the roof which could be made safe and weatherproof. Secondly, a new permanent building, 420 ft. wide by 180 ft. long and 13 ft. high to the lowest point of the roof, was erected on an adjacent site already cleared and levelled for other purposes. Thirdly, the damaged factory would be rebuilt in stages, the equipment being moved to the new building while a part of the old one was rebuilt. The equipment would then be returned to the old site, thus vacating space in the new shops for the process to be repeated. It is anticipated that everything will be finished by the middle of April, 1958.

All the work has been carried out under the direction of the architects, W. S. Hattrell and Partners, 1 Queen's-road, Coventry, with W. H. Jones and Sons Limited, Coventry, as the main contractors, and Boulton and Paul, Limited, Norwich, as the structural engineers.

FIRST AID

Two large, independent sections of the main buildings were capable of first-aid repair, and work started on them immediately. Most of the unbuckled main stanchions, consisting of two 9 in. by 3½ in. channels battened together, were badly out of plumb. Parts which were beyond repair were cut away, and stanchions which were out of plumb—some as much as 18 in.—were pulled reasonably vertical with wire cables and strainers, which were left in position. Where the lattice girders appeared unfit to span the 80 ft. between main stanchions, steel props with spreaders on the concrete floor were introduced, and bracings were fitted where necessary to keep the remaining steelwork in reasonable alignment.

While this work was being done, the remains of the protected metal roof covering, now devoid of protection, was covered with a waterproofing compound. This compound was also used to seal new glass into the steel tees, which were all that was left of the lead-covered glazing bars. To enclose the repaired areas 3 in. thick breeze blocks were built into 20 ft. walls between posts made of 5 in. by 4½ in. steel joists at 10 ft. centres. These walls reached to the normal clear height of the building. Above them salvaged corrugated steel sheets were used to make the buildings weatherproof.

After only six days of co-operative effort on the part of the principal contractors, assisted by outside firms and by Jaguar employees, the temporary repairs were completed, and the factory resumed production. It is of interest to note, incidentally, that even while temporary repairs were in progress some cars were completed and despatched. Production just prior to the fire was at a rate of 236 cars a week. Two weeks after the fire the figure was 90, and to-day, before the reconstruction is complete, it has risen to 350 to 375 cars weekly. By Easter, 1958, it is anticipated that the output will be 400 to 450 cars each week, over 60 per cent. of the production being for export.

NEW BUILDING

First-aid repairs enabled production to continue, but there remained the problem of rebuilding the 400 ft. square area of the main factory. Fortunately, an area just behind the damaged shops had already been cleared and levelled for use as a temporary park for vehicles awaiting shipment. It was decided to erect on this area a permanent building which could be used first for production, to allow the damaged section of the main building to be taken down and rebuilt, and then, when the production sections had been re-transferred back to the rebuilt shops, to house the car-finishing lines, test and despatch departments.

Detailed proposals for a new building, 420 ft. long, 180 ft. wide and 13 ft. clear height, were submitted on February 28, and approval was given on the following day. Steelwork design commenced on March 2, and was completed by March 6. Meanwhile, preliminary work had started on the site, where the first load of steel-

* See ENGINEERING, vol. 183, page 232 and subsequent letters.

work arrived on April 1. By April 18 it was possible to start fixing the roof, and on June 8 this work was finished. On July 2 the completed building was formally handed over, though a large part of it had been occupied by Jaguar production departments beforehand.

The building is made up of eight spans of 52 ft. 6 in., with internal stanchions at 30 ft. centres, and allowance has been made at the north side and the east end for future extension. It is designed on conventional lines, having a part-pitched roof with a flat top. This arrangement is economical in cost, easy to maintain, and conducive to high-speed design, fabrication and erection. The roof steelwork is designed to support occasional loads from conveyors and runways, in addition to the usual services.

To avoid glare from direct sunlight, and to provide heat insulation, the glazing is carried out with $\frac{5}{16}$ in. strengthened standard diffusing Plyglass, fixed between lead-covered glazing bars. Roof covering where it is not glazed is of Ruberoid type C galvanised steel decking, with fire-resisting insulation board and heavy felt waterproofing. Ventilation is by Colt SRC2060 ventilators in the flat portions and Colt CO2046 fire ventilators in the glazing. The latter ventilators are fitted with fusible links which open them in case of fire.

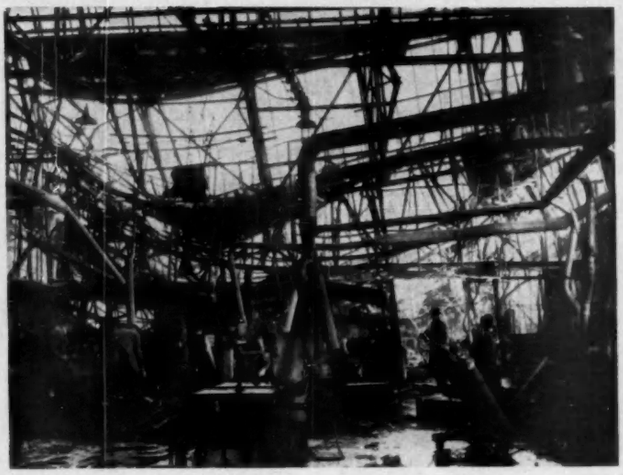
The walls on the permanent side and end are of 9 in. brickwork stiffened with brick piers, to be self-supporting without connection to the steelwork. This method of construction allows for thermal movement and for the wall to be built while the steel was being fabricated, so saving time in construction. At the temporary side and end the walls are of 9 in. brickwork to a height of 4 ft. 6 in. with Turnall asbestos combined sheeting above.

RECONSTRUCTION

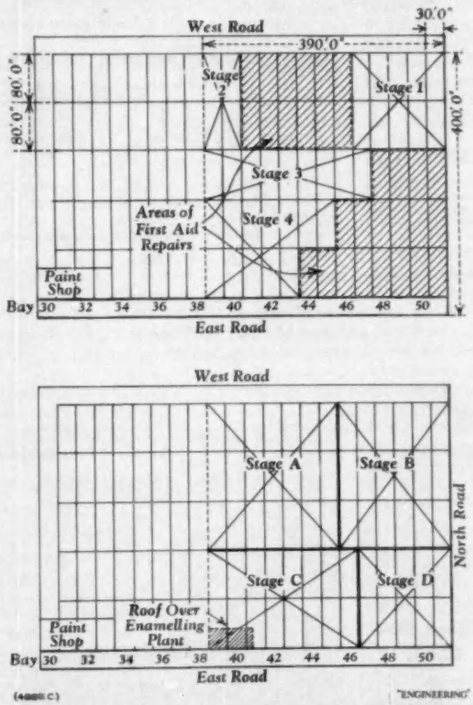
In considering the reconstruction of the main building, it appeared that if the original form was retained, much of the existing structural steelwork could be re-used. The roof was therefore rebuilt in accordance with the original plans, but the covering material was changed to Ruberoid steel decking, with fire-resisting insulation board and heavy felt waterproofing.

Demolition took place in four stages, in order to cause the least possible interference with car production. Work on stage 1 commenced on June 18, and such steelwork as could be re-fabricated was returned to the works of the structural engineers. Some items, such as purlins, could be re-used without straightening or alteration; these were marked and stacked on the site. Clearance of stages 1, 2 and 3 made it possible to start work on stage A of the rebuilding programme, and this commenced at the beginning of August. A considerable amount of temporary propping has been necessary, and it was found that about 50 per cent. of the concrete foundations and stanchion anchorages were damaged, and had to be replaced.

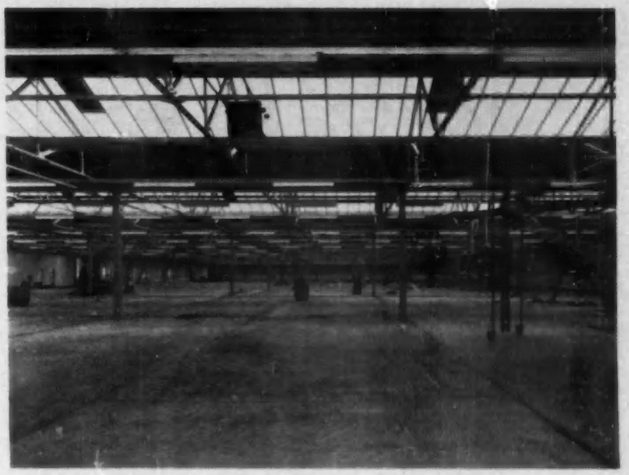
State A reconstruction was completed and handed over by the end of October, and a floor area of 230 ft. by 210 ft. was thus made available for production. To suit Jaguar's requirements, stage D is the next one scheduled for completion and it is due to be handed over ready for the production plant to be moved in during the Christmas holiday. Stage B is due for completion by the middle of January, 1958, and the entire rebuilding is expected to be finished by April.



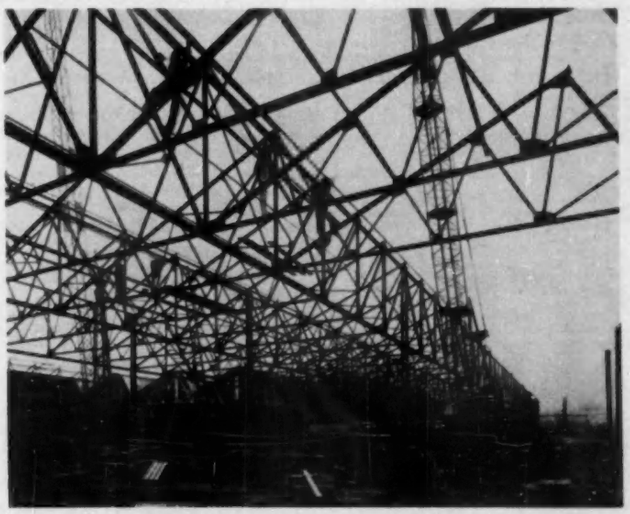
The damage suffered by the Jaguar works in the fire of February, 1957, is typified by this view of part of the sawmill.



Permanent reconstruction of the damaged building was planned in stages, four of demolition and four of rebuilding. These were taken in the order specified by Jaguar, to cause the minimum interference with production.



While first-aid repairs were effected on those parts of the main building not completely destroyed, a new building, 420 ft. by 180 ft., was erected on an adjacent site, and part of the production was transferred there.



Rebuilding is now nearing completion. The roof is being reconstructed in the old form, in order to re-use as much of the salvaged steelwork as possible.

NOTICES OF MEETINGS

British Institution of Radio Engineers

GLASGOW
"Electronic Calculator Circuitry," by F. Baillie. Scottish Section. Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank-crescent, Glasgow, C.2. Thurs., Jan. 9, 7 p.m.
NEWCASTLE-UPON-TYNE
"The Earth Satellite Project," by P. H. Tanner. North Eastern Section. Neville Hall, Westgate-road, Newcastle-upon-Tyne. Wed., Jan. 8, 6 p.m.
WOLVERHAMPTON
"Instrumentation of Space Vehicles," by N. R. Nicoll. West Midlands Section. Wolverhampton and Staffordshire Technical College, Wulfruna-street, Wolverhampton. Wed., Jan. 8, 7.15 p.m.

British Interplanetary Society

LONDON
"High Altitude Research During the International Geophysical Year," by Dr. R. F. L. Boyd. Caxton Hall, off Victoria-street, S.W.1. Sat., Jan. 4, 6 p.m.

Chemical Society

EDINBURGH
Jubilee Memorial Lecture on "The Pattern of Research in the Electrical Industry," by Dr. H. K. Cameron. Edinburgh Branch. Royal Society of Edinburgh, 24 George-street, Edinburgh. Thurs., Jan. 9, 7.30 p.m.

Combustion Engineering Association

LONDON
Brains Trust Meeting on "Coal Price Structure." Southern Region. St. Ermin's Hotel, Caxton-street, S.W.1. Wed., Jan. 8, 2.30 p.m.

Helicopter Association

LONDON
"Boost Systems for Helicopter Gas Turbines," by Dr. A. W. Morley. Royal Aeronautical Society, 4 Hamilton-place, W.1. Fri., Jan. 10, 6 p.m.

Illuminating Engineering Society

LONDON
"Lighting of Aircraft Flight Decks," by J. W. Strange and B. Stevens. Federation of British Industries, 21 Tothill-street, S.W.1. Tues., Jan. 14, 6 p.m.
CARDIFF
"Lighting for Photography," by R. W. Unwin. Cardiff Centre. Offices of the South Wales Electricity Board, The Hayes, Cardiff. Thurs., Jan. 9, 7.30 p.m.
EDINBURGH
"The Sales Engineer's Approach to Lighting," by W. J. Buriand. Edinburgh Centre. Y.M.C.A., 14 South St. Andrew-street, Edinburgh. Wed., Jan. 8, 6.15 p.m.
NOTTINGHAM
"Lighting from the Contractor's Point of View," by N. C. Slater. Nottingham Centre. Offices of the East Midlands Electricity Board, Smithy-row, Nottingham. Thurs., Jan. 2, 6 p.m.*

Incorporated Plant Engineers

LONDON
"A Practical Survey of Automatic Combustion Regulation on Industrial Boilers," by W. R. L. Kent. Royal Society of Arts, John Adam-street, Adelphi, W.C.2. Tues., Jan. 7, 7 p.m.*
BRISTOL
"Education in Industry," by E. G. Sterland. Western Branch. Grand Hotel, Bristol. Wed., Jan. 8, 7.15 p.m.
EDINBURGH
"Construction of a Welded Pipe Line," by R. Downie. Edinburgh Branch. 25 Charlotte-square, Edinburgh. Tues., Jan. 7, 7 p.m.
LEICESTER
"Smoke Abatement," by S. N. Duguid. Leicester Branch. Bell Hotel, Leicester. Wed., Jan. 1, 7 p.m.
NOTTINGHAM
"The Petroleum Industry," by J. Collins. East Midlands Branch. County Hotel, Theatre-square, Nottingham. Wed., Jan. 8, 7 p.m.
PETERBOROUGH
"Production and Maintenance in an Automobile Factory," by K. B. O'Kell. Peterborough Branch. White Lion Hotel, Church-street, Peterborough. Tues., Jan. 7, 7.30 p.m.

Institute of Fuel

LONDON
"The Influence of the Adsorption of Frothing Agent on the Percentage Recovery of Coal from Flotation Pulps," by Dr. A. Jowett. Institution of Civil Engineers, Great George-street, S.W.1. Wed., Jan. 8, 5.30 p.m.*
NEWCASTLE-UPON-TYNE
"Oil Fuel at Home," by K. S. Brett. North Eastern Section. King's College, Newcastle-upon-Tyne. Mon., Jan. 6, 6.30 p.m.
PORT TALBOT
"Planning Construction and Problems Associated with Berkeley and Dounreay Power Stations," by P. K. Richards. South Wales Section. Canteen Hall, Abbey Works, Steel Company of Wales Ltd., Port Talbot. Wed., Jan. 8, 6 p.m.

Institute of Metals

BIRMINGHAM
"Production of Rods and Shapes in Copper and Its Alloys,' by Dr. N. Swindells. Birmingham Local Section. College of Technology, Gosta Green, Birmingham. Thurs., Jan. 9, 6.30 p.m.
OXFORD
Junior Members' Evening. Discussion on "Seeing Dislocations." Oxford Local Section. Cadena Café, Cornmarket-street, Oxford. Tues., Jan. 7, 7 p.m.
SWANSEA
"Electron Microscopy," by Dr. J. W. Menter. South Wales Local Section. Department of Metallurgy, University College, Singleton Park, Swansea. Tues., Jan. 14, 6.30 p.m.*

Institute of Petroleum

LONDON
"Lubrication Problems Arising from Railway Traction Modernisation," by W. B. Broadbent and G. A. Dickins. Wed., Jan. 1, 5.30 p.m.*

Institute of Physics

LONDON
"Physical Research in the Research Group of the Atomic Energy Authority," by Dr. B. F. J. Schonland. London and Home Counties Branch. Wed., Jan. 15, 6 p.m.*
LIVERPOOL
"Radio Astronomy," by Dr. H. P. Palmer. Liverpool and North Wales Branch. Department of Electrical Engineering, The University, Liverpool. Fri., Jan. 3, 7 p.m.*
MANCHESTER
"Contact Electrification," by Dr. P. S. H. Henry. Manchester Branch. Bragg Lecture Theatre, The University, Manchester. Fri., Jan. 10, 6.45 p.m.

Institute of Refrigeration

LONDON
"Properties, Handling and Storage of Modern Refrigerants," by W. F. Bews. Junior Institution of Engineers, Pepys House, 14 Rochester-row, S.W.1. Thurs., Jan. 2, 5.30 p.m.*

Institution of Civil Engineers

LONDON
"No. 1 Berth, Tilbury Dock, Port of London Authority," by C. Peel, A. J. Carmichael and R. F. J. Smeardon. Tues., Jan. 7, 5.30 p.m.*
Dugald Clerk Lecture on "Lifting Equipment," by W. R. Hockaday. Wed., Jan. 8, 6.30 p.m.*
BIRMINGHAM
"Engineering Research at the Building Research Station," by Dr. F. G. Thomas. Midlands Association. James Watt Memorial Institute, Great Charles-street, Birmingham 3. Thurs., Jan. 9, 6 p.m.
EDINBURGH
"The Engineer's Influence on Town Planning," by Alex. T. McIndoe. Edinburgh and East of Scotland Association. North British Hotel, Edinburgh. Wed., Jan. 8, 6 p.m.
NOTTINGHAM
"A New Approach to Building," by D. E. E. Gibson. East Midlands Association. College of Arts and Crafts, Waverley-street, Nottingham. Wed., Jan. 8, 6.15 p.m.

Institution of Electrical Engineers

LONDON
"The Breakdown of Transformer Oil under Impulse Voltages," by Dr. R. Hancox and Dr. H. Tropper. Measurement and Supply Sections. Tues., Jan. 7, 5.30 p.m.*
"Development of Variable-Speed High-Power Drives for Large Wind Tunnels," and "A Variable-Frequency Power Installation for Large Wind-Tunnel Drives," by P. McKearney, L. S. Drake and E. G. Mallalieu; "Speed Control of Large Wind Tunnels, with Particular Reference to the R.A.E. 8 ft. by 8 ft. High-Speed Wind Tunnel," by L. S. Drake, J. H. Fox and G. H. A. Gunnell; and "Data-Setting and Electrical Control Gear for the Flexible Nozzle and Diffuser of a High-Speed Wind Tunnel," by C. R. Dunham. Thurs., Jan. 9, 5.30 p.m.*
Address by the President, T. E. Goldup. London Graduate and Student Section. Mon., Jan. 6, 6.30 p.m.*
BIRMINGHAM
"Electrical Equipment for Rectifier Locomotives," by H. Calverley, E. A. K. Jarvis and E. Williams. South Midland Centre. James Watt Memorial Institute, Great Charles-street, Birmingham. Mon., Jan. 6, 6 p.m.*
FARNBOROUGH
"Colour Television," by C. J. Stubbington. Southern Centre, R.A.E. Technical College, Farnborough. Wed., Jan. 8, 6.30 p.m.
LEEDS
Various short papers on "Transistors," by C. Adamson and L. M. Wedephol. North Midland Centre. Offices of the Yorkshire Electricity Board, 1 Whitehall-road, Leeds. Tues., Jan. 7, 6.30 p.m.
LIVERPOOL
"British Columbia to Vancouver Island 138 kV Submarine Power Cable," by Dr. T. Ingledow and others. Mersey and North Wales Centre. Royal Institute, Colquitt-street, Liverpool. Mon., Jan. 6, 6.30 p.m.

Institution of Heating and Ventilating Engineers

LONDON
"Survey of Methods of Pressurisation for Medium and High-Pressure Hot-Water Systems," by J. R. Kell. Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, S.W.1. Thurs., Jan. 9, 6 p.m.*
NEWCASTLE-UPON-TYNE
"Air Filtration: Why and How," by G. H. Vokes. North East Coast Branch. Neville Hall, Westgate-road, Newcastle-upon-Tyne. Tues., Jan. 7, 6.30 p.m.

Institution of Highway Engineers

NORWICH
"Steel: Modern Applications of Rolled Sections," by F. G. Ward. East Anglia Branch. Assembly House, Norwich. Tues., Jan. 7, 6.30 p.m.

Institution of Mechanical Engineers

LONDON
"Design and Development of Four Lightweight High-Speed Marine Gas Turbines for Electric Generator Drive," by A. W. Pope; and "Developments in Methods of Measuring Stresses in Compressor and Turbine Blades on Test Bed and in Flight," by D. A. Drew. Meeting in conjunction with the Internal Combustion Engine Group. Fri., Jan. 10, 6 p.m.*
LOUGHBOROUGH
Annual General Meeting. "Numbers, Statistics and Computers in the Engineering Industry," by H. McGregor Ross. East Midlands Branch. Loughborough College of Technology, Greenclose-lane, Loughborough. Wed., Jan. 8, 7 p.m.
LUTON
"Pneumatic Suspensions for Motor Vehicles," by J. Sainsbury. Luton A.D. Centre. Town Hall, Luton. Wed., Jan. 8, 7.30 p.m.

Institution of Naval Architects

LONDON
Amos Ayre Lecture: "The Evolution of the Cargo Ship During the last 35 Years and Some Thoughts on the Years to Come," by Dr. J. Ramsay Gebbie. Thurs., Jan. 9, 4.45 p.m.*

Institution of Production Engineers

CHATHAM
"Pneumatic Circuiting," by H. C. Orchard. Rochester Section. Sun Hotel, Chatham. Thurs., Jan. 9, 7.30 p.m.
LEICESTER
"The Use of Plastics in Industry," by B. E. Terry. Leicester Section. Grand Hotel, Leicester. Thurs., Jan. 9, 7 p.m.
LIVERPOOL
"Inspection as an Aid to Production," by W. Maiden. Liverpool Section. Exchange Hotel, Tithebarn-street, Liverpool 2. Wed., Jan. 8, 7.30 p.m.
STAINES
"Practical Approach to Engineering Fine Surfaces," by D. B. Ebsworth. Reading Section. Social Club, Petters Ltd., Staines. Thurs., Jan. 9, 7.30 p.m.

Institution of Structural Engineers

LONDON
"The Calculation of Bending and Torsional Effects in Girders," by J. S. Terrington. Thurs., Jan. 9, 6 p.m.*
BRISTOL
"Construction of a Prestressed-Concrete Circular Tank," by G. B. Smedley. Western Counties Branch. University Engineering Laboratories, The University, Bristol. Fri., Jan. 3, 6 p.m.*
MANCHESTER
"Shrinkage in Soils," by E. Ll. Morgan. Lancashire and Cheshire Branch. College of Science and Technology, Manchester. Tues., Jan. 7, 6.30 p.m.*

Junior Institution of Engineers

LONDON
Film Evening. Fri., Jan. 3, 7 p.m.*
"Brewing and Distilling," by T. F. Luck. Fri., Jan. 10, 7 p.m.*

Leeds Metallurgical Society

LEEDS
"Corrosion Problems and Water Treatment in Power Stations," by R. W. Wolforth. Chemistry Wing, The University, Leeds 2. Thurs., Jan. 9, 7.15 p.m.

Newcomen Society

LONDON
"Travel Diaries of Swedish Engineers of the Eighteenth Century as Sources of Technological History," by Michael W. Flinn. Wed., Jan. 8, 5.30 p.m.

North East Coast Institution of Engineers and Shipbuilders

NEWCASTLE-UPON-TYNE
"University Education in Marine Engineering," by Professor G. H. Chambers. Mining Institute, Newcastle-upon-Tyne. Fri., Jan. 10, 6.15 p.m.

Sheffield Metallurgical Association

SHEFFIELD
Annual General Meeting of the Methods of Analysis Group, and address by the new chairman of the Group. B.I.S.R.A. Laboratories, Hoyle-street, Sheffield. Tues., Jan. 7, 7 p.m.

Society of Chemical Industry

LONDON
"Stress Corrosion Cracking," by T. P. Hoar and J. C. Hines Corrosion Group. Wed., Jan. 15, 6.30 p.m.

Society of Instrument Technology

LONDON
"Design of Cascade Control Systems," by R. L. Day. Control Section. Manson House, 26 Portland-place, W.1. Thurs., Jan. 9, 7 p.m.
CHELTENHAM
Discussion on "Nickel Alloys for Instrument Production." Cheltenham Section. The Rotunda, Cheltenham. Tues., Jan. 7, 7.30 p.m.
FAWLEY
"Instruments Applied to Nuclear Power," by K. R. Sandiford. Fawley Section. Copthorne House, Fawley, Hants. Fri., Jan. 3, 7 p.m.

South Wales Institute of Engineers

CARDIFF
"Some Aspects of the Design and Erection of Skyscraper Buildings," by L. G. Johnson. Thurs., Jan. 9, 6 p.m.

The address and telephone number of the headquarters of each institution are given below. Meetings in the headquarters town are held there unless otherwise stated. Particulars for this column should reach the Editor not later than Monday morning in the week preceding the date of the meeting.

* An asterisk is placed where it is understood that tea is available prior to the time stated.

British Institution of Radio Engineers, 9 Bedford-square, London, W.C.1. (MUSeum 1901.)
British Interplanetary Society, 12 Bessborough-gardens, London, S.W.1. (TATe Gallery 9371.)
Chemical Society, Burlington House, Piccadilly, London, W.1. (REGent 0675.)
Combustion Engineering Association, 6 Duke-street, St. James's, London, S.W.1. (WHItehall 5536.)
Helicopter Association of Great Britain, 4 The Sanctuary, London, S.W.1. (ABBey 5160.)
Illuminating Engineering Society, 32 Victoria-street, London, S.W.1. (ABBey 5215.)
Incorporated Plant Engineers, 12 The Parade, Solihull, Warwickshire. (Solihull 1111.)
Institute of Fuel, 18 Devonshire-street, Portland-place, London, W.1. (LANgham 7124.)
Institute of Metals, 17 Belgrave-square, London, S.W.1. (BELgravia 3291.)
Institute of Petroleum, 61 Cavendish-street, London, W.1. (LANgham 2250.)
Institute of Physics, 47 Belgrave-square, London, S.W.1. (BELgravia 6111.)
Institute of Refrigeration, New Bridge Street House, New Bridge-street, London, E.C.4. (CENtral 4694.)
Institution of Civil Engineers, Great George-street, London, S.W.1. (WHItehall 4577.)
Institution of Electrical Engineers, Savoy-place, Victoria-embankment, London, W.C.2. (TEMple Bar 7676.)
Institution of Heating and Ventilating Engineers, 49 Cadogan-square, London, S.W.1. (SLOane 3158.)
Institution of Highway Engineers, 47 Victoria-street, London, S.W.1. (ABBey 3891.)
Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, London, S.W.1. (WHItehall 7476.)
Institution of Naval Architects, 10 Upper Belgrave-street, London, S.W.1. (SLOane 4622.)
Institution of Production Engineers, 10 Chesterfield-street, London, W.1. (GROsvenor 5254.)
Institution of Structural Engineers, 11 Upper Belgrave-street, London, S.W.1. (SLOane 7128.)
Junior Institution of Engineers, Pepys House, 14 Rochester-row, London, S.W.1. (VICtoria 0786.)
Leeds Metallurgical Society. Apply to Dr. P. Feltham, The University, Leeds.
Newcomen Society, Science Museum, Exhibition-road, London, S.W.7. (KENsington 1793.)
North East Coast Institution of Engineers and Shipbuilders, Bolbec Hall, Newcastle-upon-Tyne 1. (Newcastle 20289.)
Sheffield Metallurgical Association, 66 Ringstead-crescent, Sheffield 10. (Sheffield 62144.)
Society of Chemical Industry, 14 Belgrave-square, London, S.W.1. (BELgravia 3681.)
Society of Instrument Technology, 20 Queen Anne-street, London, W.1. (LANgham 4251.)
South Wales Institute of Engineers, Park-place, Cardiff. (Cardiff 23296.)

In Parliament

MOUNTING PRODUCTION IN ENGINEERING

Some striking facts and figures in relation to productivity in the engineering, shipbuilding and electrical goods industries were given to the House of Commons a few days ago by Mr. Nigel Birch, the Economic Secretary to the Treasury. Even allowing for the upward trend in prices over recent years, the figures indicate that the rise in production in these industries has been significant.

For one thing, the index of productivity for the three industries, taken as 100 for the year 1948, stood at a level of only 54 in 1935, but had risen to no less than 155 by 1955. Gross output in £ million mounted from 350 in 1935, to 1,620 in 1948, and to 3,289 in 1955. The net annual output per person employed rose from £224 in 1935, to £522 in 1948, and to £814 in 1955, an increase of over 260 per cent. during the twenty years. Wages did even better. Whereas the average wage amounted to no more than £120 per annum in 1935, it had risen to £310 in 1948 and to £490 in 1955, an increase of nearly 310 per cent. during the same period of years.

The figures for gross output, Mr. Birch told Mr. Ellis Smith (Labour), were not free from duplication, since they necessarily included sales between different establishments in the industrial group referred to. Such sales were estimated, for 1948, as amounting to about 6 per cent. of the total.

THE GENERAL PICTURE

As a background to this development in the engineering and associated industries, Mr. Birch gave some figures relating to the national economy and although these statistics related to slightly different years, they did much to complete the general picture.

Consumers' total expenditure, in £ million, amounted to 4,394 in 1938, rising to 7,909 in 1947, and to 13,409 in 1956, of which the amounts spent on food were 1,285; 2,104; and 4,376 respectively. In other words, while the total sums spent by British consumers increased by 205 per cent. during the 18 year period, the proportion spent on food alone increased by 241 per cent. The nation's gross domestic product, also in £ million, was 4,983 in 1938, rising to 9,273 in 1947, and to 17,939 in 1956; an increase of 260 per cent. over the period.

Gross fixed capital formation in Britain in £ million rose from 656 in 1938, to 1,199 in 1947, and to 3,139 in 1956; an increase of 379 per cent. Figures for the value of physical increase in stocks and work in progress for 1938 were not available, but for 1947 the value was £330 million and, for 1956, £250 million. Exports of merchandise, in £ million, were 533 in 1938, rising to 1,145 in 1947, and to 3,403 in 1956; an increase of 538 per cent. Services and suchlike invisible exports mounted from £190 million in 1938, to £311 million in 1947 and to £961 million in 1956; an increase of 406 per cent. These details were derived from a variety of sources, including the Government's censuses of production.

AIRCRAFT INDUSTRY INQUIRY

A number of members, including Mr. Frank Beswick (Labour/Co-operative), pressed Mr. Aubrey Jones, the Minister of Supply, for some additional information regarding the inter-departmental committee set up to investigate the future of Britain's aircraft industry.

Mr. Aubrey Jones told them that the purpose of the study, by senior officials of the Government departments concerned, was to assess the national importance of the industry and, in the light of that assessment and of recent defence changes, to make recommendations to Ministers on future Government policy towards the industry and, in particular, in respect to the scale on which the Government should continue to support aeronautical research. As decisions were reached, Mr. Aubrey Jones said, he would make statements and he was hopeful that he would be able to make a statement in relation to the question of aeronautical research before the spring of next year.

It would militate against early decisions to formalise the inter-departmental study and to arrange for representations by bodies outside the Government. He was always happy, however, to receive personally leaders of trade unions and employers, and the views of both would be borne in mind when decisions were made. The inter-departmental study would certainly take into account the possibility of diversifying the industry's products, but action on this aspect of the industry's future lay primarily with the industry itself.

The study being undertaken was not dominated by the Treasury but it was really difficult, of course, to exclude the Treasury from any major question of Government policy. On the subject of achieving a greater integration within the industry, Mr. Aubrey Jones considered that the industry's own concern about its future well being and the power of awarding contracts possessed by the Government as the industry's largest customer should do much to bring about such integration.

AERONAUTICAL ENGINEERS' FUTURE

Other members, including Mr. Cyril Bence (Labour), inquired about the consideration being given to the aircraft industry in Scotland, and were told by Mr. Aubrey Jones that the industry there had been less affected by recent changes in the defence programme than it had elsewhere. As to the future, Scottish companies, and firms with factories in Scotland, would be given every opportunity of competing for contracts as they became available. It followed that, although the industry in Scotland was relatively well placed, it would have to face some degree of contraction. He had indicated to the Blackburn Aircraft Company, Limited, that the Government would like to lease their part of the entire factory at Dumbarton to a fresh tenant, but no such tenant had yet been found.

Mr. Ian Mikardo (Labour) wished to know what steps were being taken to ensure that the services of technical and managerial personnel throughout the industry, who might be rendered redundant by the coming running-down in the industry, would not be lost to the country. On this point, Mr. Aubrey Jones said that it was not the policy of the Government to prevent emigration, but one of the purposes of the defence changes was to release skilled personnel for the many other needs existing for them in this country. It was the Government's hope that engineers and scientists displaced would take advantage of the opportunities awaiting them here. As stated previously, he endeavoured to let the industry know of impending changes as soon as they were decided officially and, as far as he was aware, firms took their staffs into their confidence.

Appreciation of the Minister's "very full" statement was expressed by Mr. Beswick. He considered that it would do much to give satisfaction to those who were interested in the industry.

I.C.E. CONFERENCE ON ROADS

Mr. Ernest Davies (Labour) drew the attention of the Minister of Transport and Civil Aviation to the conference on British highway problems which had taken place in London recently under the auspices of the Institution of Civil Engineers. He pointed out that the conference had reached the conclusion that an expenditure of about £350 million a year for the next ten years would have to be incurred upon new construction and major improvement work, if roads in this country were to be rendered adequate to meet the probable traffic which they were likely to have to carry at the end of that period. He pressed Mr. Harold Watkinson to arrange for the planning section of his ministry to consider the whole matter, so that an early statement could be made indicating how the problem of future road needs would be tackled. Mr. Watkinson said that the conclusions of the conference, which he did not necessarily accept, were now being examined by his department.

TECHNOLOGICAL COURSES

A request was made by Mr. Michael Stewart (Labour) that particulars should be published showing the numbers of students, during each of the last six years, who had entered on courses leading to technical qualifications. He also wanted to know how many of these students had abandoned their courses before completion, and how many students had failed to secure the qualifications concerned on the completion of the courses. Mr. Geoffrey Lloyd, the Minister of Education, reported that this information was not available.

In reply to another question by Mr. Stewart regarding technical courses, Mr. Lloyd stated that 30,459 students were now pursuing courses at colleges of advanced technology. Of that number, 5,957 students were full-time. He was unable to state, however, to what extent financial provision for these people was made from public funds and from private industry.

Abandoned Aircraft Projects

Military aircraft projects which have been abandoned as a result of recent changes in the Government's policy are the supersonic bomber, a supersonic fighter, and a research aircraft proposal, according to an answer given by Mr. Aubrey Jones, the Minister of Supply, to Mr. Frank Tomney (Labour).

Short Brothers and Harlands

In answer to another question, by Mr. Arthur Woodburn (Labour), regarding the future of Short Brothers and Harland Limited, Belfast, and of the firm's design team, Mr. Aubrey Jones stated that it was the Government's wish that Short and Harland's should continue as a fully-balanced aircraft-production unit. Everything practicable to that end was being done both by the firm itself and by the Government. Success, however, must depend primarily upon the quality and cost of the company's work relative to that of other companies; and the Government could not be expected to place contracts, even with their own firm, regardless of that consideration.

Purfleet to Dartford Tunnel

Definite progress is being made in the construction of the tunnel connecting Purfleet with Dartford, according to an answer given by Mr. G. R. H. Nugent, Joint Parliamentary Secretary to the Ministry of Transport and Civil Aviation, to Mr. John Parker (Labour). Mr. Nugent stated that tunnelling had been commenced on both sides of the river, and that the shields had been driven for over a hundred yards. A steady advance was being made in the building of the approach road on the Kent side, and the ground was being levelled on the Essex side.

Railway Electrification

In the course of other answers, Mr. Nugent referred to the progress being made in railway electrification. He told Mr. Kenneth Robinson (Labour) that the re-phasing of capital investment in connection with the railway modernisation plan was unlikely to affect the Euston-to-Glasgow electrification scheme. British Railways' estimate that the Euston-to-Rugby section would be completed in 1967 was unchanged. He told Mr. John Parker that the programme of preliminary works for the electrification of the Tilbury line, from Fenchurch Street Station, was up to schedule. In addition, the new marshalling yard at Ripple Lane should be completed by the end of next year, and the re-modelling of the junctions at Barking by the end of 1959. Other works were going ahead steadily.

The Human Element

T.U.C.'s Seasonable Gesture

At its meeting last week the economic committee of the T.U.C. decided to recommend to the General Council that they should see the "three wise men" who comprise the Cohen committee on wages, prices and production. This is the second conciliatory gesture which has come from this quarter in the last few weeks. The last one was a very restrained pronouncement on the Government's economic policy. The T.U.C. does not always reflect closely the climate of opinion in the unions, but on this occasion it gives some hint at the prevailing feeling among responsible union officials that they should neither burn their boats on economic policy nor cry before they are hurt on wage negotiations.

Peace and goodwill are likely to descend upon the industrial scene over the Christmas season for of the two main danger points for industrial strife, the railways and the London buses, only the latter has been active in December. The timing of the railwaymen's wage moves have been upset by the untimely death of the N.U.R. president and general secretary. So far as the Transport and General Workers Union are concerned, the London men have put their general secretary in a difficult position for either he must support a claim he does not favour, and so appear to have his hand forced by his own members, or preach moderation to a membership which is ill disposed to listen. It may yet be a bleak and brooding festive season at Transport House.

Those Technical Diplomas

Some progress has been made by the 11 colleges which are preparing students for the Diploma in Technology. Reviewing the first year's work of the National Council for Technological Awards, Lord Hives, who is the Council's chairman, said that the colleges had been doing a good job, often in difficult and depressing circumstances. They now needed "stimulation and encouragement." These difficulties, and their implications for the future supply of technologists to industry are discussed in the leading article in last week's issue (page 737). At the end of November, 965 students were attending 37 courses recognised as leading to the new "Dip.Tech." qualification. "This, of course, is only a beginning," said Lord Hives, "we must aim at many times more than that."

The Government's plans to expand the technical colleges were described as "ambitious and imaginative," but Lord Hives warned that a great deal had still to be done at the colleges before a first-class system of advanced technical education can be said to have been established on a country-wide basis. But he sees also the need for a more complete education for those who will be the technical managers of the future. "We have got to build a lot of new buildings," he said, "strengthen the teaching staffs, introduce a more liberal atmosphere into the education, and develop much closer links between the colleges and industry."

The movement to produce more and better scientists and technologists is well under way. The danger is that it should take too long in gathering momentum through lack of financial support, that it should be misunderstood and its products mis-used by industry itself.

Halcyon Days?

The statisticians have just reminded us that only 2·05 million days were lost in 1956 because of strikes—the best year since 1952. With the strike weapon so much under discussion at the present time as a likely phenomenon in 1958 it is as well to savour these statistics while one may. Figures for 1957 are not yet available, but they are likely to have been rather worse than 1956 owing to the outbreak of strikes last spring in the shipbuilding industry and elsewhere. Compared with other countries Britain has a good record of recent years on industrial disputes and we lose more on sickness each year than on strikes.

The strike, as an industrial weapon, is much less used than once it was. In the three years immediately after the first world war the average annual number of days lost was 49·1 million. The average of 1922 to 1932 was 7·6 million and the worst post-war year, which was 1955, recorded 3·8 million. From these figures it is clear that the unions have used the strike weapon much less as a final arbiter. This may be because the unions have greater funds to lose and the men larger pay packets and a higher standard of living at stake. These two matters might yet have an important influence on the industrial climate in 1958.

Sub-Conscious Protected

At last some action has been taken to protect the individual's mind from the advertiser's back-door tactics. Some time ago the Federal Communications Commission in the United States announced that they would make a study of subliminal perception. Whether or not this has been done has not been stated but the three United States television networks—National Broadcasting, Columbia Broadcasting and American Broadcasting—have announced that they will not accept or use subliminal advertising. In principle, this is a welcome move for there appeared to be no other defence against this new weapon in the unending fight for the customer's allegiance.

Subliminal advertising flashes messages on the screen so quickly that they are not consciously seen but are nonetheless absorbed by the subconscious mind of the viewer. The possible application of such techniques for capturing the support of electors, for example, is a serious threat to the rights of people to make up their own minds in a conscious manner. What would happen if our subconscious was subjected to the unseen onslaught of rival brands or opposite points of view is anyone's guess.

The decision taken by the United States television networks was in accordance with a recommendation made by the National Association of Radio and Television Broadcasters. Their code-review board considered that experiments with, or use of, subliminal perception on television should not be permitted pending review and consideration by the Board of any proposal to use it. The Columbia Broadcasting Systems were even more categorical in their attitude: "The legal, social and ethical implications raised by subliminal perception, as we understand it, are sufficient to preclude its use in any form on the C.B.S. television network and our company-owned stations." Perhaps this is the end of a dangerous experiment; one wonders, however, how the networks will spot an unscrupulous advertiser who provides a film containing such material.

Unifying the Naval Reserves

A unified reserve, to be called the Royal Naval Reserve, is to be made out of the existing R.N.R. and R.N.V.R. The First Lord of the Admiralty said last week that the main reason for the change is to streamline and strengthen the naval reserve. There is a useful economy involved of £600,000 a year and it is difficult to believe that this has not been an important consideration. There is, however, likely to be scope for worthwhile cuts in expenditure when two organisations have worked on broadly similar training lines over the years and have developed distinctive traditions. One other break with the past is the decision to use shore-based rather than floating establishments.

While regretting the fusion (hence the passing) of two great naval traditions there is one important point for the future in this move for all concerned with technical training. It is to be hoped that work done on combining courses and rationalising teaching staff will in due course be made public along with the results achieved. The Services are not the only organisations these days who must spread their resources more thinly, streamline training programmes and make innovations in training methods. Industry is faced with a similar problem and could well learn from naval experience.

Tradition in Offices

The annual conference of non-manual workers of the T.U.C. which met last week had a good deal to say about the need for legislation to improve office conditions. So much has been said over the last century about improving working conditions in factories that office conditions are apt to go by default.

Office conditions could often well be improved but the reasons for "slum" conditions are various. Some offices are badly over-crowded because trades cling to traditional (and hence cramped) quarters in big towns. The merchanting quarters in London, Manchester or Liverpool are examples of this. Some are over-crowded because clerical workers will put up with bad offices provided salaries and bonuses are good. Some office workers accept bad conditions as part of the white-collar workers' burden, a type of snob appeal. Finally, there are traditions of bad office accommodation in certain industries, where the shop floor is considered the thing that matters, or on the railways (which have probably a unique collection of "horror huts") where the offices have had to fit themselves in to odd corners left by the railway lines and turn-tables.

The private members' bill on the subject due to come up this session will be worth careful examination. Legislation on minimum conditions of employment is overdue.

Professional Remuneration

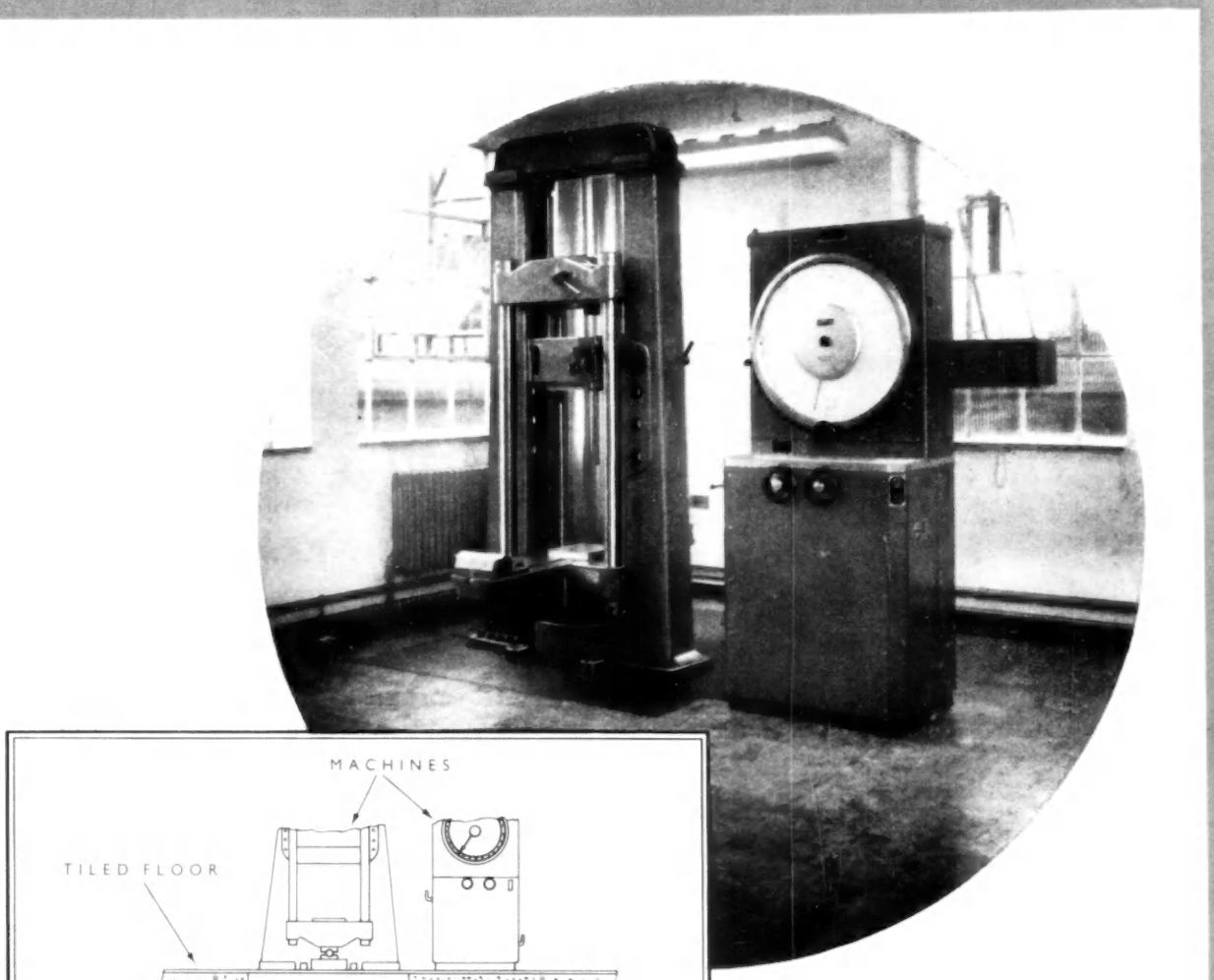
The Royal Commission on Doctors' and Dentists' Remuneration, under the chairmanship of Sir Harry Pilkington, have held their first meeting. They heard evidence submitted on behalf of the Socialist Medical Association and the Whole-Time Consultants' Association.

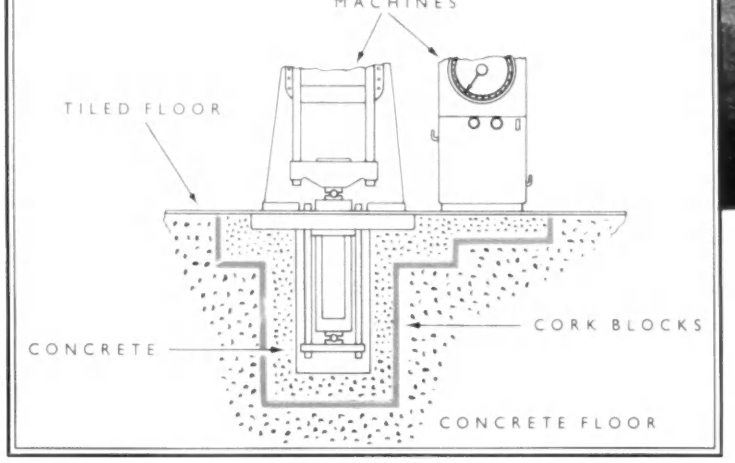
The S.M.A., who claim 470 doctors among their active and associate membership, urge that all members of the profession should be employed on a salaried basis. They are concerned, they say, "with principles rather than precise amounts of remuneration." Consultants and specialists should be treated in the same way, and not employed by hospitals on a part-time basis. The Association consider all practices which lead to "side-earnings," such as the pay-bed system, should be abolished.

The Whole-Time Consultants' Association criticised the differences in remuneration between the part-time and whole-time consultant. The considerably greater financial inducement offered to the former, they argued, had "an important and damaging effect upon the hospital service." If further evidence from other bodies contains criticisms of the present system as fundamental as these, the Commission will be faced with major problems of re-organisation. Perhaps this is the only way to deal with a situation which appears to have got so completely out-of-hand. If doctors will behave like wage earners, the least they can expect is to be treated like salary earners: a point to be remembered by all who might wish to claim the advantages of belonging to a profession.

ENGINEERING

An Illustrated Weekly Journal





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